AD-A146 795 MINNESOTA RIVER AT CHASKA MINNESOTA FLOOD CONTROL 1/6
PROJECT GENERAL DESIGN..(U) CORPS OF ENGINEERS ST PAUL
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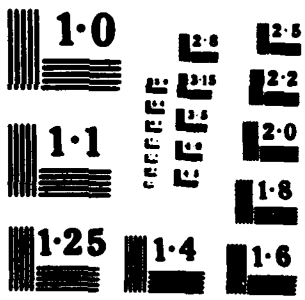
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AD-A146 795

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER

2. GOVT ACCESSION NO. A146 795

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle)
MINNESOTA RIVER AT CHASKA, MINNESOTA FLOOD CONTROL PROJECT: General desigh memorandum and draft supplement II to the final environmental impact statement.

5. TYPE OF REPORT & PERIOD COVERED

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)

8. CONTRACT OR GRANT NUMBER(s)

9. PERFORMING ORGANIZATION NAME AND ADDRESS
U.S. Army Engineer District, St. Paul
1135 USPO & Custom House
St. Paul, MN 55101-1479

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS

11. CONTROLLING OFFICE NAME AND ADDRESS

12. REPORT DATE
Feb 1984; Rev. August 1984

13. NUMBER OF PAGES

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)

15. SECURITY CLASS. (of this report)
UNCLASSIFIED

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Supersedes AD-A 119480 and ADA 119481

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)
FLOOD CONTROL
ENVIRONMENTAL IMPACT STATEMENTS
MINNESOTA RIVER
CHASKA, MINNESOTA

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The project is located on the Minnesota River in Carver County and Chaska, Minnesota, and includes both Chaska and East Creeks, which are tributaries of the Minnesota River. The plan for flood protection for the city of Chaska provides for structural measures: upgrading and extending the existing levee system around Courthouse Lake; construction of a pumping station; diverting Chaska and East Creeks; construction of a drop structure and inlet and outlet structures associated with the two diversions.

The most significant environmental impact is the replacement of the natural streambed of Chaska Creek with a reinforced concrete channel. Other impacts include restriction of public access to the wildlife refuge, the loss of about 20 acres of floodplain forest and the residential relocations. To help offset the environmental losses, the plan would include several mitigation features such as: habitat improvement measures in the refuge, planting plan on project lands, landscaping and beautification measures.

NCDED-T (19 Mar 84) 3rd Ind
SUBJECT: Flood Control, Minnesota River at Chaska, Minnesota, General Design Memorandum

DA, North Central Division, Corps of Engineers, 536 South Clark Street, Chicago, Illinois 60605-1592 23 JUL 1984

TO: Commander, St. Paul District ATTN: NCSED-M

1. Reference: 23 April 1984 NCSED-M letter, subject: Chaska GDM Comment Responses.

2. Referred for appropriate action.

3. NCD comment 57 is withdrawn. The referenced responses furnished for the NCD geotechnical, hydraulic and environmental comments are satisfactory with the exception of the response to NCD comment 4. The modification of Highway Bridge 41 should be reevaluated to determine its advisability.

FOR THE COMMANDER:

ZANE M. GOODWIN, P.E.
Chief, Engineering Division

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DEPARTMENT OF THE ARMY
ST PAUL DISTRICT CORPS OF ENGINEERS
1135 U S POST OFFICE & CUSTOM HOUSE
ST PAUL MINNESOTA 55101

REPLY TO
ATTENTION OF:

NCSED-M

9 March 1984

SUBJECT: Flood Control, Minnesota River at Chaska, Minnesota, General Design Memorandum

Commander, North Central Division
ATTN: NCDED-T

1. The subject report presents designs and discussions of engineering studies and draft supplement II to the final environmental impact statement for flood control improvements on the Minnesota River at Chaska, Minnesota, and is submitted in accordance with ER 1110-2-1150.

2. Submission of this report has been accelerated from the original milestone schedule. This was to allow time for the approvals necessary to qualify the project as an FY 86 construction new start.

3. I have met with officials from the city of Chaska to discuss project sponsorship. The city understands and fully supports this project. They have indicated their interest in participating in cost-sharing at a percentage of total project costs which conforms to the cost-sharing policy developed by the Administration and the Congress for flood control projects.

Edward G. Rapp

EDWARD G. RAPP
Colonel, Corps of Engineers
Commanding

NCDED-T (19 Mar 84) 1st Ind
SUBJECT: Flood Control, Minnesota River at Chaska, Minnesota, General Design Memorandum

19 APR 1984

DA, North Central Division, Corps of Engineers, 536 South Clark Street, Chicago, Illinois 60605

TO: Cdr, USACE (DAEN-ECE-B) WASH DC 20314

1. Subject document is forwarded recommending conditional approval subject to the inclosed comments and the completion of the NEPA requirements. The Draft Supplement II to the Final Environmental Impact Statement will be filed with the U.S. Environmental Protection Agency by St. Paul District.

2. The Chaska project is economically feasible and it has a great deal of local support. It is requested that every effort be made to insure that this project meets the requirements for inclusion in the FY 1986 Budget as a new construction start.

JBHilmes

2 Incl
as

JEROME B. HILMES
Brigadier General, USA
Commanding

NCD'S COMMENTS

ON

CHASKA, MN
Phase II GDM

1. Paragraph 20, Page A-6. A debris basin should be designed upstream from the supercritical channel on Chaska Creek. Passage of large debris through the concrete channel can cause overtopping and subsequent erosion damage. The basin should also help contain the design flow (SPF) in the channel by providing positive entry into the supercritical channel.

2. Paragraph 7, Page A-2. Plates 4A-9 to 4A-18 and other Plates referenced in the text should be made part of this report.

3. Paragraph 11, Page A-2. What are the consequences of overtopping the Minnesota River Levees? What will happen when the design flow is exceeded? Are we worsening existing conditions. What are the Emergency Plans? These plans should be in the report.

4. Table A-2, Page A-4. Provide a rationale in the report on why the 100-year, 500-year, and the Standard Project Flood under Project condition are greater than future conditions.

5. Table A-1, Page A-4. The different subwatersheds should be shown on a map and should be made part of the report.

6. Sedimentation, especially on East Chaska Creek, should be addressed in the report.

7. Paragraph 25, Page A-8:

   a. The letter k denotes relative roughness height and not Chezy's.

   b. To prevent unacceptable waves due to unstable flow conditions when flow is at or near critical depth, the ratio of the normal depth to critical depth should be less than or equal to 0.9, or the ratio of the invert slope to critical slope should be greater than 1.29.

   c. Check the instability of low flows using equations 10 and 11 and Plate 7 of EM 1110-2-1601.

   d. The denominator gy of the equation shown should be gR where R is the radius of curvature. Provide a legend of the symbols used in the formula.

   e. Determine the minimum length of the upstream spiral transitions required for each of the curves in the channel alignments and show them on the drawings together with the superelevation and banking.

   f. The design of the channel should consider air entrainment which can cause the flow to bulk and necessitate higher wall heights. Refer to Paragraph 16 and Plate 45 of EM 1110-2-1601 and HDC-050-3.

COMMENTS ON CHASKA, MN - Phase II GDM (Continued)

g. Consider conducting a model study for the supercritical channel because of the uncertainty in the magnitude of wave heights that will be reflected back and forth across the channel for long distances on the downstream tangents.

h. Check the freeboard requirements based on the energy content and velocity of flow using the emperical relationship on Page 76 of EM 1110-2-1603.

8. Paragraph 41, Page A-13. The side drainage outlets should be angled towards the direction of the channel flow to minimize turbulence. Means for precluding backflow through the side drainage should be installed. Due to the fast rising nature of Chaska Creek flooding back flow prevention should be automatic, i.e., flap gate.

9. Paragraphs 41-47, Pages A-13 to A-14. Show on drawings details of the side drainage appurtenances such as the control structure, ogee crest, tranquil and rapid flow channels, side channel spillway inlet, etc., with dimensions.

10. Paragraph 50, Page A-16. Show drawings of the transitions from rectangular to trapezoidal riprap channel to natural. Riprap extremeties should be anchored in accordance with Plates 37 and 38 of EM 1110-2-1601.

11. Paragraph 52, Page A-16. Riprap protection should be designed in accordance with ETL 1110-2-120 and EM 1110-2-1601. Provide velocity and discharge information for the various flood events investigated.

12. Paragraph 58, Page A-18. The formula used in the head loss computation assumes full pipe flow. A pipe rating curve, starting with open channel flow for low flow to full pipe flow, should be prepared and compared with the entrance rating curve to see where the control is for a given flood event.

13. Paragraph 60, Page A-19. Provide velocity information for the various flood events investigated to see if the grass lining is sufficient to withstand the tractive forces generated.

14. Paragraph 61, Page A-17. The drop structures proposed in this report should be designed to withstand flanking which is the common cause of failure for this type of structure.

15. Paragraph 67, Page A-20. The water surface profile stability should have been analyzed during the feasibility stage because the magnitude of flooding determines potential project benefits and the degree of protection needed. This information should definitely be made available now.

16. Paragraphs 2 to 5, Page B-1. Sections 1-4 are on Plate B-1. Refer to it in the text.

17. Paragraph 48, Page B-13. Provide a summary of the interior flood control evaluation showing annual cost, annual benefit, benefit cost ratio, net benefit and residual damages for the various plans and various frequency floods investigated.

COMMENTS ON CHASKA, MN - Phase II GDM (Continued)

18. Paragraph 9, Page C-2. After borings are obtained along East Creek a design of all structures in this area should be submitted along with borings.

19. Paragraph 10, Page C-2. In addition to the deep borings, other shallow borings should be obtained in landward toe area in order to better define the blanket characteristics for relief well design or other alternatives.

20. Paragraph 19, Page C-3. From the computation sheet (Figure 1 through Figure 36) it appears that minimum in situ thickness of the blanket is 6.5' (Figure 21), but in Paragraph 19, the minimum thickness is stated to be 4'. Please clarify the situation.

21. Paragraph 20, Page C-4. When fines of 4 to 12 percent or more are present the D10 method might not be accurate. Run permeability tests on typical material of this type from new borings.

22. Paragraph 21, Page 21, Figures 2, 4. Adjacent to the levee between stations 73+00 and 95+18, Chaska Creek will be relocated in concrete channel and the existing course of the creek will be filled up. Such construction would eliminate the possibility of seepage entering to the pervious layer as stated in the last sentence of paragraph 21. In analysis of uplift pressure at the landward toe of the levee, seepage entry from the creek should not be considered. In computing L1, and X1 in Figures 2 & 4 consideration must be given to the effect of concrete channel in cutting off the entry of seepage to the pervious layer and the permeability of the fill materials which forms the new blanket between the proposed levee and the concrete channel.

23. Paragraph 23, Page C-4. From the description given in Paragraph 23, it is not possible to determine the extent of Reach 3. Please give reference of the drawing number on which these reaches are shown.

24. Paragraph 25, Page C-4. Please give reference of the drawing number on which the extent of Reach 4 is shown.

25. Paragraph 27, Page C-5. Computations for foundation settlement should be submitted.

26. Paragraph 31, Page C-5. The structural design appendix does not show anything pertaining to the East Creek Outfall.

27. Paragraph 32, Page C-6. Previous DM's have emphasized that the existing levee was not up to Corps standards (no compactions, frozen material, etc.) and no protection could be certified. Therefore, before building on to the existing levee it must be shown conclusively that this old construction is satisfactory. This should be discussed thoroughly.

28. Paragraph 34, Page C-6. Restudy the need for relief wells after securing more borings to better define the aquifer and the blanket material. Relief well should be avoided if at all possible because of installment and maintenance cost. Discuss all alternatives including a drainage trench.

a. The analyses for factor of safety provided in Figures 9, 18 are questionable. Please provide justification for not considering the submerged weight of the in situ layers above the least pervious layer in computing the factors of safety.

b. The design analyses for pervious seepage berm provided in Figures 10, 16 and 17 do not satisfy the requirements of EM 1110-2-1913. According to the April 1981 revisions to EM 1110-2-1913, the upward gradient Io (Page C-3) should be 0.5 instead of 0.3.

c. The analyses .. factor of safety against uplift and those of seepage berms should be revised considering the facts stated in (a) and (b).

29. Paragraph 38 through 45. Design analysis for the concrete channel and appurtenant structure's, including the method used to account for siol-structure interaction, should be submitted with FDM.

30. Paragraph 39, Page C-7. The design of a system to relieve uplift pressure should be submitted for review. The effect of icing should be discussed thoroughly.

31. Paragraph 48, Page C-8. a. Borings should be obtained for the bridge foundations.
b. Locations of the four proposed bridge with-proper identification must be shown on Plate - 1. From the statement made in Paragraph 48, it is hard to locate the four proposed bridge structures.

32. Paragraph 49, Page C-8. No detailed features have been provided for rectangular concrete channel to be provided in Reach 4.

33. Paragraph 50, Page C-8. Provide pertinent design analysis for the levee to be provided in Reach 4.

34. Paragraph 52, Page C-9. Plate 29 is not attached to the GDM and as such it is not possible to review the profile of the box culvert.

35. Paragraph 55, Page C-9. Plate 27 is not attached to the GDM.

36. Paragraph 56, Page C-9. Location of two proposed bridges to be built in Reach 4 must be shown on Plate-1 with proper identification. Plate-31 has not been attached to the GDM.

37. Paragraph 58, 59, 60, and Plate C-12, Page C-10. Soil strength parameter used for region-1 in the slope stability analysis shown on Plate C-12 should be obtained by testing specimen from compacted soil from borrow area, at pertinent moisture content. Final stability analysis should be performed using the strength parameter of the soil which will be used for constructing the levee. Stability of the levee slope at all critical locations should be evaluated including the levee along East Chaska Creek.

38. Paragraph 60, Page C-10. The Phase I report on page 5-13 listed steady seepage and partial pool as critical cases. These cases should also be presented for review in this document.

39. Paragraph 66b, Page C-11. Explain why this is considered satisfactory material.

40. Paragraph 66c & 66d, Page C-11. Justify the excavation of weak soils to elev. 690. Discuss other alternatives.

41. Paragraph 66e, Page C-11. Show computation for the berm design. Consider stage construction and discuss this alternative. Computation for other berm widths and thicknesses should be shown. It should be shown that this is the optimum berm width.

42. Paragraph 71, Page C-14. Revisions to Levee Manual Em 1110-2-1913 require berm minimum widths plus the base width of the levee to be 15 times the height of the levee. This would permit berm widths on this project to be less than 150 feet. Check on this new criteria and see if berms can be extended to replace wells in places.

43. Paragraph 75, Page C-16. Present settlement computations for review. For one location, longhand settlement computations should be done and compared with that obtained by computer.

44. Figure 13 and elsewhere.

a. The permeability of the SP-Sm material should be checked from tests to see if it should be considered part of the blanket. If around 10×10^{-4} Cm-sec it should be considered part of the blanket and new computations furnished. In this case relief wells might not be necessary.

b. Since the permeability of this material could be relatively low, it could be difficult for wells spaced 50 to 75 feet apart to protect the toe from uplift and a trench drain could be more effective. Study this possible alternative and discuss.

45. Page I-1. A summary of past flood events and of levee performance should be presented.

46. Page I-1. to I-5. This is a much improved method for evaluating existing levees. This exercise and resulting data should be submitted in the planning reports.

47. Paragraph 10a, Page I-2. The word "Certified" should be omitted. If the COE certifies even their own levess many lawsuits could result against the Government.

48. Paragraph 23, Page I-5. This statement may or may not be true and should be eliminated. Poor COE construction has been observed and good construction by others is possible.

COMMENTS ON CHASKA, MN - Phase II GDM (Continued)

49. Econ. App. App. E. Phase II GDM Economic Appendices should contain a tabular summary of the changes in estimated benefits which track from the previous Phase I GDM report. This should include identifying changes due to price level adjustments and interest rates. Price level indices used should be noted in the text or in footnotes. Changes due to such factors as design changes, flood frequency estimates, etc., should also be separately tabulated and identified. Add.

50. Recreation Benefits, App. G. The evaluation in the recreation appendix has not been updated to current price levels and interest rates. Revise and provide updated recreation benefits using the FY84 user day value point schedule (copy attached of EC 1105-2-126, page A-21) and an interest rate of 8-1/8 percent.

51. Page 21, Non-Fed Costs. A pro-rated portion of E&D and S&A costs should be allocated to the non-Federal cost estimate.

52. Interest During Const., pages 21, 24, and 26. Details of the computation of interest during construction should be added. In particular, interest during construction for each of the three major stages should be shown separately. Also, interest during construction should be computed using at least semi-annual compounding. The total cost for FY84-89 funding schedule on page 26 does not add up to the total project first cost on page 21. Check and revise.

53. Page EIS-7, paragraph 3.05. The identification of Engler Blvd. is absent on Plate 1, which makes it difficult to locate the modifications identified. In addition, the GDM & DEIS descriptions are difficult to follow on Plate I. An expanded legend needs to be added identifying all features of the proposed project, including recreation features.

54. Page EIS-14, paragraph 4.18. Coordination with the MDNR concerning State listed threatened and endangered species should have been initiated during earlier stages of this EIS. Information regarding the accuracy of these species in the project area and anticipated impacts to these species <u>must</u> be included in the final supplemental EIS.

55. **Pages 26-27 - Items of Local Cooperation —**

Revise Items a, b (except the part after "project"), c, d, e, f, g, and h to read the same as Items a, c, d, e, f, b, g and h respectively in H.D. 94-644.

56. **Paragraph 43, Railroad Relocation —**

The feature design memorandum should contain an attorney's report.

57. **GDM paragraph 52 and EIS paragraph 3.11 state that mitigation will be implemented on Federal land. How is this justified in light of local cooperation Item a. which requires that the sponsor furnish all lands, easements and rights-of-way <u>without cost to the United States</u>.**

57. **Page G-14, paragraph 40 —**

Since the project specifically has recreation as a purpose, the reference to the 1944 FCA is questioned.

Revised Table VIII-3-1 (FY1984) Conversion of Points to Dollar Values

Activity Categories	POINT VALUES 0	10	20	30	40	50	60	70	80	90	100
General Recreation (Points from Table VIII-3-2)	1.60	1,90	2.20	2,60	2,90	3,50	3,80	4,10	4,30	4.60	4,90
General Fishing & Hunting (Points from Table VIII-3-2)	2,40	2.60	2,90	3,10	3,50	3,80	4.10	4,50	4.70	4.80	4.90
Specialized Fishing & Hunting (Points from Table VIII-3-3)	11,40	11,70	12.00	12,30	12.60	13.70	14,90	16,10	17.20	18,40	19.60
Specialized Recreation Other than Fishing & Hunting (Points from Table VIII-3-3)	6.50	7.10	7.60	8.10	8.70	9.80	10.90	13.00	15.20	17.40	19.60

NOTE: See ER 1105-2-40, Change 2, 9 Jul 83, pages A-67 & A-68 for Table VIII-3-2 and VIII-3-3.

DAEN-ECE-B (19 Mar 84) 2nd Ind
SUBJECT: Flood Control Minnesota River at Chaska, Minnesota, General Design Memorandum

HQ, U. S. Army Corps of Engineers, Washington, D.C. 20314 6 June 1984

TO: Commander, North Central Division, ATTN: NCDED-T

1. Approved, subject to full compliance with NEPA requirements and procedures set forth in ER 200-2-2, the comments of the Division Commander transmitted with the 1st indorsement, and to the comments furnished in the following paragraphs.

2. NCD Comment 57 (Enclosure No. 2). We see no problem with mitigation being implemented on Federal land. The lands to be used for mitigation purposes are already in Federal ownership, and their use for this purpose is consistent with current Corps policy, thus, eliminating the need for additional acquisition.

3. Paragraph 44 and Plates 10 and 11, Road Relocations. Data for the bridges are given in this paragraph and shown on the plates. However, the details of these structures should be furnished in Appendix D. Details on the new and old bridges for First Street and Hickory Street should be provided in order that clear understanding of the recommended plan can be achieved.

4. Paragraph 88. The annual costs for operations and maintenance should be identified in this paragraph.

5. Paragraph 90. A discussion or statement on the responsibilities for operation and maintenance of the pumping plant should be furnished.

6. Plate 9, Chaska Creek Energy Dissipator. The details of this structure should be shown in the same scope as for the East Creek Culvert Outlet on Plate 20.

7. Appendix A.

a. Plate A-22. Water surfaces profiles on this plate should be shown in the same detail as the water surface profiles were set forth on Plate A-20. The profiles should extend to the upstream end of the project and show the effects of the stages on the Minnesota River.

b. Side Drainage, pertinent plates in main report and in Appendix A. The overland flow should be addressed and shown as specified in paragraph 6j of ER 1110-2-1405.

c. Paragraphs A-39 and A-72 and NCS response to NCD comment 1, Debris Barrier. Details of the debris barriers for both Chaska and East Creeks should be furnished. Consideration should be given to providing means for controlling the accumulation of snow and ice at the culvert entrance and for eliminating the chance of a person being drawn into the culvert.

DAEN-ECE-B (19 Mar 84) 2nd Ind 6 June 1984
SUBJECT: Flood Control Minnesota River at Chaska, Minnesota, General Design Memorandum

8. Appendix B, Interior Flood Control. It is noted in paragraph B-53 that interior flood control facilities will be refined. Accordingly, all comments on interior flood control are deferred until information on this refinement is received and reviewed in OCE. Construction on the subject project should not commence until the interior drainage has been approved by OCE. Data should be furnished in accordance with the guidance set forth in EC 1110-2-247.

9. Paragraph 41, Appendix G. Payments must be either "up front" or contributed in kind which is consistent with the guidance furnished in letter DAEN-CWO-R, 27 June 1983, subject: "Negotiation of Recreation Cost Sharing Contracts."

10. In the future, the sequencing of plan and profile sheets should be accomplished in accordance with paragraph 11e of ER 1110-2-1002.

FOR THE COMMANDER

Jack R. Thompson

wd all encl

for WILLIAM N. McCORMICK, JR.
Chief, Engineering Division
Directorate of Engineering and
Construction

23 April 1984

NCSED-M

SUBJECT: Chaska GDM Comment Responses

Commander, North Central Division
ATTN: NCDED-T

1. References:

a. NCDED-T telecopy dated 29 March 1984, subject: Minnesota River at Chaska, Minnesota, Flood Control Project (Environmental Comments).

b. NCDED-T telecopy dated 4 April 1984, subject: Minnesota River at Chaska, Minnesota, Phase II GDM (Hydraulics/Hydrology Comments).

c. NCDED-T telecopy dated 6 April 1984, subject: Minnesota River at Chaska, Minnesota, Flood Control Project (Geotechnical Comments).

2. Inclosed are our responses to the above-cited comments.

FOR THE COMMANDER:

1 Incl
as

PETER A. FISCHER
Chief, Engineering Division

12 April 1984
Chaska GDM

NCD GEOTECHNICAL COMMENTS
(Dated 3-27-84)

Comment 1: After borings are obtained along East Creek, a design of all structures in this area should be submitted along with the borings.

Response: Concur.

Comment 2: In addition to the deep borings, other shallow borings should be obtained in landward toe area in order to better define the blanket characteristics for relief well design or other alternatives.

Response: Concur.

Comment 3: When fines of 4- to 12-percent or more are present, the D_{10} method might not be accurate. Run permeability tests on typical material of this type from new borings.

Response: The D_{10} method made use of the best available data. While it is agreed that this method may not be the most accurate to determine the permeability of all soils, it is probably as accurate as other testing considering the problems associated with recovering undisturbed samples of this material. In the FDM a comparison of results obtained using the D_{10} method and using permeability values published in literature for such material will be made, as per the conference call of 9 April 1984.

Comment 4: Computations for foundation settlement should be submitted.

Response: Concur. A complete computer solution (using "CSETT") on foundation settlement computations will be submitted for all pertinent locations in the FDM. A hand verification will also be furnished at that time.

Comment 5: Previous DM's have emphasized that the existing levee was not up to Corps standards (no compaction, frozen material, etc.) and no protection could be certified. Therefore, before building on to the existing levee it must be shown conclusively that this old construction is satisfactory. This should be discussed thoroughly.

Response: Concur. Existing borings and any new borings taken through the levee will be utilized to evaluate the existing levee for the FDM.

Comment 6: Restudy the need for relief wells after securing more borings to better define the aquifer and the blanket material. Relief wells should be avoided if at all possible because of installment and maintenance cost. Discuss all alternatives including a drainage trench.

Response: Concur. The FDM will include a finite element analysis for seepage/uplift computations. Relief wells and other alternatives will be studied to optimize effectiveness and minimize costs.

Comment 7: The design of a system to relieve uplift pressure should be submitted for review. The effect of icing should be discussed thoroughly.

Response: Concur. This will be presented in the FDM.

Comment 8: Borings should be obtained for the bridge foundations.

Response: Concur. They will be presented in the FDM.

Comment 9: The Phase I report on page 5-13 listed steady seepage and partial pool as critical cases. These cases should also be presented for review in this document.

Response: Concur. Time restraints and funding did not allow presentation of a complete stability analysis in this report. A complete analysis will be presented in the FDM at all pertinent locations.

Comment 10: Explain why this is considered satisfactory material.

Response: This material is a glacial till and as such would be suitable for use in the proposed project.

Comment 11: Justify the excavation of weak soils to elevation 690. Discuss other alternatives.

Response: Concur. Excavation and other alternatives will be discussed and justified in the FDM.

Comment 12: Show computation for the berm design. Consider stage construction and discuss this alternative. Computations for other berm widths and thicknesses should be shown. It should be shown that this is the optimum berm width.

Response: Concur. The berm design will be optimized and the alternatives discussed in the FDM.

Comment 13: Revisions to Levee Manual EM 1110-2-1913 require berm minimum widths plus the base width of the levee to be 15 times the height of the levee. This would permit berm widths on this project to be less than 150 feet. Check on this new criteria and see if berms can be extended to replace wells in places.

Response: Concur. Revisions to EM 1110-2-1913 will be obtained and the new criteria will be included in the analysis performed for the FDM.

Comment 14: Present settlement computations for review. At least at one location a hand settlement computation should be done and compared with that obtained by computer.

Response: Concur. Settlement computations will be furnished and verified in the FDM.

Comment 15(A): The permeability of the SP-SM material should be checked from tests to see if it should be considered part of the blanket. If around 10×10^{-4} cm/sec it should be considered part of the blanket and new computations furnished. In this case relief wells might not be necessary.

Response: Do not concur. Testing of this material is not practical since sample recovery is so difficult. As discussed, in the response to comment 3, the seepage computations in the FDM will reflect a comparison of D_{10} values vs. permeability values typically found in literature for this material.

Comment 15(B): Since the permeability of this material could be relatively low it could be difficult for wells spaced 50 to 75 feet apart to protect the toe from uplift and a trench drain could be more effective. Study this possible alternative and discuss.

Response: Concur. However, it is unlikely that a trench drain will be effective against an aquifer over 120 feet deep. Additional analysis will be performed for the FDM, and the engineering solution chosen will be analyzed using finite element methods to determine the effectiveness of the final design.

Comment 16: A summary of past flood events and of levee performance should be presented.

Response: Concur.

Comment 17: The word "Certified" should be omitted. If the COE certifies even their own levees many lawsuits could result against the Government.

Response: Concur. The word "evaluated" will be substituted for "certified."

Comment 18: This statement may or may not be true and should be eliminated. Poor COE construction has been observed and good construction by others is possible.

Response: Do not concur. The statement does not reflect on the construction practices of anyone, including the Corps. The statement merely emphasizes that the evaluation was based on assumptions and engineering judgment rather than on geotechnical analysis and design criteria; and, therefore, a greater level of risk must be accepted.

Comment 19: This is a much improved method for evaluating existing levees. This exercise and resulting data should be submitted in the planning reports.

Response: Concur, that the evaluation of existing levees should be presented in planning documents. However, since the geotechnical evaluation was based on assumptions and engineering judgment instead of geotechnical analysis and design criteria, District geotechnical personnel do not believe that the method establishes a proper base for economic evaluation of a project and, therefore, do not consider the method to be an improved method.

NCD GEOTECHNICAL COMMENTS
(Dated 4-4-84)

Comment 1: From the computation sheet (Figure 1 through Figure 36) it appears that minimum in-situ thickness of the blanket is 6.5' (Figure 21), but in paragraph 19, the minimum thickness is stated to be 4'. Please clarify the situation.

Response: The minimum in-situ thickness of the landside blanket is actually 3.5 feet as shown on Figure 7. The in-situ blanket is designated by soil classification symbols. The "FILL" designations are proposed conditions, and the numbers following these designators are possible blanket conditions if the area was filled to the given elevation. Table 1 shows a summary of the in-situ blanket thicknesses by figure number.

Table 1

In-situ Blanket Thicknesses**
as Shown on Figures 1-36 in Appendix C

Applicable Figure No.	In-situ(Z_t) Blanket Thickness (feet)	Landside Ground Surface Elevation	Existing Factor of Safety
1	12.5	720.0	2.66
3	9.7	715.0	1.76
5	10.25	709.5	1.79
7	3.5*	708.5	0.70
11	5.0	710.0	1.36
13	5.0	710.0	0.43
21	6.5	713.0	0.71
26	4.1	710.2	0.39
31	5.6	710.0	0.49
36	8.9	711.2	1.58

*Minimum blanket thickness.
**Note: See Plate C-10 for subsurface profile of aquifer.

Comment 2: Adjacent to the levee between stations 73+00 and 95+18, Chaska Creek will be relocated in concrete channel and the existing course of the creek will be filled up. Such construction would eliminate the possibility of seepage entering to the pervious layer as stated in the last sentence of paragraph 21. In analysis of uplift pressure at the landward toe of the levee, seepage entry from the creek should not be considered. In computing L1, and X1 in Figures 2 and 4 consideration must be given to the effect of concrete channel in

cutting off the entry of seepage to the pervious layer and the permeability of the fill materials which forms the new blanket between the proposed levee and the concrete channel.

Response: Concur. However, the computations performed yielded adequate factors of safety for uplift pressures under very conservative seepage entrance assumptions.

Comment 3: From the description given in paragraph 23, it is not possible to determine the extent of Reach 3. Please give reference of the drawing number on which these reaches are shown.

Response: Concur. Reach 3 is the entire reach of Chaska Creek and it is shown on Plates 9 through 13 of the main report. Plate 1 will be revised to locate all reaches discussed and proposed new bridges shown.

Comment 4: Please give information of the drawing number on which the extent of Reach 4 is shown.

Response: Concur. Reach 4 is the entire reach of East Creek and it is shown on Plates 15 through 23 of the main report. Plate 1 will be revised as indicated in the response to comment 3.

Comment 5: The structural design appendix does not show anything pertaining to the East Creek Outfall.

Response: Concur. The write-up was not revised to reflect last minute changes due to time restraints. The entire East Creek design was deferred to completion in the FDM.

Comment 6(a): The analyses for factor of safety provided in Figures 9, 18 are questionable. Please provide justification for not considering the submerged weight of the in-situ layers above the least pervious layer in computing the factors of safety.

Response: Refer to the response to comment 1. The unified soil classification symbols are the in-situ soils that make up the existing blanket. The "FILL" designations represent proposed conditions and they should be neglected for the computations in Figures 9 and 18 because no fill will be used. The computation of Figure 18 is further complicated by the geometry of the section. A seepage block was assumed to exist at X_3 = 335 feet (a conservative assumption resulting in the closer well spacing).

Comment 6(b) and (c): (b) The design analyses for pervious seepage berm provided in Figures 10, 26 and 17 do not satisfy the requirements of EM 1110-2-1913. According to the April 1981 revisions to EM 1110-2-1913, the upward gradient Io (Page C-3) should be 0.5 instead of 0.3. (c) The analyses for factor of safety against uplift and those of seepage berms should be revised considering the facts stated in (a) and (b).

Response: Concur. The District is obtaining a copy of the revisions to EM 1110-2-1913 and will include the new criteria in computations completed for the FDM.

Comment 7: Design analysis for the concrete channel and appurtinant structures including the method used to account for soil-structure interaction should be submitted with FDM.

Response: Concur.

Comment 8: Locations of the four proposed bridge with-proper identification must be shown on Plate - 1. From the statement made in paragraph 48, it is hard to locate the four proposed bridge structures.

Response: Concur. Plate 1 will be revised.

Comment 9: No detailed features have been provided for rectangular concrete channel to be provided in Reach 4.

Response: Concur. All detailed features of Reach 4 are to be presented in the FDM on Reach 4.

Comment 10: Provide pertinent design analysis for the levee to be provided in Reach 4.

Response: Concur. Design analysis will be presented in the FDM.

Comment 11: Plate 29 is not attached to the GDM and as such it is not possible to review the profile of the box culvert.

Response: Concur. Plate 29 does not exist; the correct plate numbers are 20 and 21.

Comment 12: Plate 27 is not attached to the GDM.

Response: Concur. Plate 27 does not exist; the correct plate number is 19.

Comment 13: Location of two proposed bridges to be built in Reach 4 must be shown on Plate 1 with proper identification. Plate 31 has not been attached to the GDM.

Response: Concur. Plate 1 will be revised. Plate 31 does not exist; the correct pate numbers are 22 and 23.

Comment 14: Soil strength parameter used for Reach 1 in the slope stability analysis shown on Plate C-12 should be obtained by testing specimens from compacted soil from borrow area, at pertinent moisture content. Final stability analysis should be performed using the strength parameter of the soil which will be used for constructing the levee. Stability of the levee slope at all critical locations should be evaluated including the levee along East Chaska Creek.

Response: Concur. After a borrow area is identified, the final stability analysis will be performed for the FDM.

HYDRAULICS AND HYDROLOGY RESPONSES FOR THE CHASKA, MINNESOTA,
PHASE II GDM,
5 APRIL TELECOPY COMMENTS FROM NCDED-W

Comment 1: The need for a debris barrier will be examined in the design memorandum as mentioned in paragraph A-39 of the GDM.

Comment 2: Concur. As mentioned in paragraph 7, page A-2, Plates 4A-9 to 4A-18 from the limited reevaluation report are inclosed. In addition, paragraph 6, page A-2 makes reference to Plates 4A-7 and 4A-8 of the limited reevaluation report, also inclosed.

Comment 3: The consequences of overtopping would be minimized since the city has an emergency plan and there is significant warning time if the levees are going to be overtopped. Refer to paragraph 19, page A-5 this report and page 94 (inclosed) section on Level of Protection and SPF Conditions in main part of the previus report titled Limited Reevaluation Report.

Comment 4: Concur. Paragraph 9, page A-2 discusses the Highway 41 embankment with its attendant storage effects for existing and future conditions. As the project condition assumes a bridge to be in place, this storage is then converted to unattenuated flow, and a larger downstream peak results. Highway 41 was initially discussed in the Interim Survey Report, August 1973, pages 31, 32, 37, 38, 43, D-2 and D-9, inclosed. Also inclosed is the report of the BERH, dated 9 July 1974, with a statement about Highway 41 in paragraph 14.

Comment 5: Concur. Plate 4A-1 from the limited reevaluation report is inclosed.

Comment 6: Sedimentation (channel stability) is addressed on pages 4B-15 and 4B-16 (inclosed) of the Appendix B of the Limited Reevaluation Report and paragraph 70 on page A-21 of this report. Aggradation and degradation are not currently significant problems on East Chaska Creek. The proposed channel modifications and drop structures will be designed to match preproject water surface profiles upstream of the drop structures, and the channel will be stabilized with riprap and concrete in the modified channel reach, so sedimentation should not be a significant problem after the project is complete. The East Creek Feature Design Memorandum will include further discussion on sedimentation and the maintenance of the new East Creek diversion plan.

Comment 7a: Concur. Future reports will be written accordingly.

Comment 7b: As stated in paragraph A-25, the flow is adequately supercritical by the Froude number criteria in EM 1110-2-1601. The normal depth to critical depth ratio is .77, less than 0.9, and the invert slope to critical slope ratio is 2.09, greater than 1.29. These values are based on the worst case maximum roughness, k = .0084 ft.

Comment 7c: Stability was checked for a range of flows from depths of 1.0 foot to the design depth, 6.6 ft. From plate 7 of EM 1110-2-1601 all flows with depths grater than 2.0 feet were stable. Flows with depths of 1.0 and 2.0 were on the line between stable and unstable. Any minor formation of slugs at these small depths would not adversely affect the project.

Comment 7d: Concur that the denominator should be gr rather than gy. Legend from page 28 of EM 1110-2-1601 is as follows:

y = rise in water surface between theoretical level water surface at the center line and outside water surface elevation.

c = coefficient (see page 28 of EM 1110-2-1601).

v = mean channel velocity.

w = channel width at elevation of center-line water surface.

g = acceleration of gravity.

r = radius of channel center-line curvature.

Comment 7e. Proposed radii of curves and banking are shown on plates 9-12. A table of required curve data follows:

PI	Approx Station	Min Length Spiral (ft)	Min Radius (ft)	Superelevation (ft)	Banking (ft)
3	28+04	22.2	410	.74	1.48
4	39+88	20.1	390	.67	1.34
5	50+79	20.1	390	.67	1.34
6	55+24	20.1	390	.67	1.34
7	59+93	18.0	980	.67	1.20

Minimum radii are based on low friction loss. Superelevation and banking are based on average losses and the actual design radii.

Comment 7f: A check by Plate 45 of EM 1110-2-1601 indicates there will be no bulking of flow because the design Froude numbers are less than 1.7 for all flow conditions.

Comment 7g: The St. Paul District does not feel a model study is needed. The proposed supercritical flow channel is designed for the standard project flood and has a simple rectangular form with no obstructions. No curves have radii less than the minimum recommended in EM 1110-2-1601 and all curves are to be banked and have spiral transitions. The conservative design of the bends should eliminate or reduce the cross-wave distrubance pattern, reference Chow's Open-Channel Hydraulics, article 16-7. Long straight sections are also proposed upstream of the inlet structure between the inlet and the most upstream curve, between curves that are in opposite directions (station 48+90 to 40+51) and at the downstream end between the last curve and the stilling basin. Because of this conservative design, the chance of significant overtopping of the walls is small and because of the location of the channel anything less than major overtopping would not cause major or catastrophic damages. The channel is adjacent to the levee in only the lower portion and the levee is on the inside of the bend, reducing the chance for significant overtopping flow to attack it. Also, the levee is designed to protect against the Minnesota River 100-year flood and the likelihood of coincident large floods on both the creek and the river is very remote.

Comment 7h: The freeboard obtained from the equation on page 76 of EM 1110-2-1603 is 3.1 feet versus the proposed 2.0 feet. The equation in EM 1110-2-1603 is to be used for chute spillways for reservoirs where the damages associated with failure are usually very high or catastrophic. As explained in the response to comment 7g, the risks are much lower for the Chaska Creek channel and the freeboard allowance can be reduced. The proposed 2.0 feet is considered reasonable.

Comment 8: The side drainage outlets are angled towards the direction of the channel flow and the left side drainage outlet includes a gate well with flap gate, see plate 10. The right side outlet is a side channel spillway inlet designed like that shown on plate 53 of EM 1110-2-1601 with flow entering the channel above the design water surface.

Comment 9: Details of the side channel spillway inlet will be shown in the feature design memorandum. Feature design memorandum studies to date have resulted in this drainage outlet being moved and redesigned,

thus, developing drawings of the structures described in the GDM would not be productive.

Comment 10: Concur. Drawings of channel transitions are shown on plates 21 through 23 of the main report. Plate 37 of EM 1110-2-1601 does not apply since we are riprapping the bottom of the channel. End protection as shown on plate 38 of EM 1110-2-1601 will be provided in the Feature Design Memorandum.

Comment 11: Concur. Riprap was designed in accordance with ETL 1110-2-120 and EM 1110-2-1601. However, this design is preliminary and will be updated in the Feature Design Memorandum. Design velocities for the Standard Project Flood discharge of 6200 cfs are 5.1 to 8.3 fps for the riprapped channel and 11.9 to 12.4 fps for the rectangular concrete channel.

Comment 12: Concur. Additional information will be provided in the FDM (such as outlet control and outlet control rating curves).

Comment 13: The grass lined channel was designed for maximum channel velocities of 6 fps. The channel design will be refined in the Feature Design Memorandum.

Comment 14: Concur. The drop structure is designed to withstand flanking.

Comment 15: Concur. The water surface profile for East Creek is expected to be stable. Degradation of the channel bottom will be prevented with riprap and concrete erosion protection. The existing channel upstream is fairly stable (see pages 4B-15 and 4B-16 of the Limited Reevaluation Report) and sediment aggradation will be minor. Velocities in the concrete and riprapped channels will be high enough to remove minor sediment deposits during flood events if vegetation is not allowed to become established. Further analysis of the water surface profile stability in the Feature Design Memorandum would not affect the economic analysis and degree of protection selected for East Creek. The project is economically feasible with standard project flood protection for East Creek.

Comment 16: The fact that the interior flood control basin is shown on plate B-1 is stated in the last sentence of paragraph 1, page B-1. Therefore, it was felt not necessary to reference plate B-1 in paragraphs 2 through 5.

Comment 17: As stated in paragraph 51, page B-14, average annual benefits and costs, benefit-cost ratios and average annual net benefits are summarized in table B-19. Residual damages for the pumping rates considered for section 2, section 3 and sections 2 and 3 combined are shown on plates B-32, B-33 and B-34, respectively.

.NCSPD-ER AND NCSPD-ES RESPONSES TO NCDPD-ER COMMENTS
DRAFT SUPPLEMENT II, MINNESOTA RIVER AT CHASKA, MINNESOTA
FLOOD CONTROL PROJECT

1. Comment 1, page EIS-1, paragraph 5 - The first sentence, "Supplement II . . . regulations and guidance" is confusing. It implies NEPA and Section 404 were established subsequent to the preparation of the 1976 FEIS.

Response: Concur. Correction made.

2. Comment 2, page EIS-1, paragraph 1.02 - There are numerous "blanks" throughout the text which reference previous discussions, page numbers, other documents, etc. which should be added prior to public distribution.

Response: Concur. Corrections made.

3. Comment 3, page EIS-1, paragraph 1.03 et al page EIS-25, paragraph 5.32 - The statement that the proposed design is not in compliance with EO 11988 is in error if the statement ". . . there are no practicable alternatives . . . " is correct.

Response: Concur. Correction made.

4. Comment 4, page EIS-2 and EIS-3, table 1 - This table would be more correctly located after the discussion in paragraph 1.07 (page EIS-4). The compliance of the LAWCON statute should be "full" by the time the FEIS is distributed to the public. The EO 11988 compliance columns appear in error (see comment 3 above). The last entry (USFWS Special Use Permit) should be omitted since it is not required and is N/A to this project.

Response: We agree with the first part of this comment; however, since table 1 was juxtaposed on two facing pages so it would look better, we do not feel it would be practical to relocate it. USFWS Special Use Permit has been deleted from table 1.

5. Comment 5, page EIS-7, paragraph 3.01 - Since this EIS supplement is incorporating by reference an August 1982 supplement and a July 1975 FEIS, these documents should be readily available to the reviewers. It is suggested that the Supplement I and 1975 EIS be circulated with Supplement II to the State and agency reviewers and known interested groups/individuals. All others on the mailing list should be made aware of central depositories (libraries, government offices, etc.) or its availability in the NCS office. The dates of the FEIS are noted as July 1975 and 1976.

Response: State and agency reviewers should already have copies of previous documents or have access to them in agency files or libraries. Everyone on the mailing list will be notified of the location and availability of previous documents in libraries or in the NCS office when the letters of availability of the DSEIS go out to the public.

6. Comment 6, page EIS-7, paragraph 305 - The identification of Engler Boulevard is absent on Plate 1 which makes it difficult to locate the modifications identified. In addition, the GDM and FEIS description are difficult to follow on Plate 1. An expanded legend needs to be added identifying all features of the proposed project, including recreation features.

Response: "Engler Boulevard" was inadvertently left off Plate 1. Plate 1 is being updated to include identification of all important features of concern.

7. Comment 7, page EIS-8, paragraph 3.07 - It is not clear what "downstream end" impacts will be studied - what is the significance of these resources? Why are we delaying their inclusion into the project now? How do we propose to handle the NEPA requirements? Is mitigation required?

Response: Paragraph 3.07 acknowledges the presently-proposed East Creek design is preliminary and conservative and, as such, is considered to have "worst case" environmental impacts. The present mitigation plan is designed to compensate for this level of impacts. Although a design modification which would lessen environmental impacts may require less mitigation, it is not possible to determine if mitigation requirements will change at this time. A NEPA document addressing the final design will be prepared and coordinated with the feature design memorandum. In addition, full coordination with the USFWS and MDNR will occur during preparation of the FDM and a determination of whether or not minor adjustments to the mitigation plan will be required will be made at that time.

8. Comment 8, page EIS-12, paragraph 4.08 - The scientific names of the species should be added or referenced to previous document.

Response: Scientific names have been added to the text as appropriate.

9. Comment 9, page EIS-18, section 5 - A discussion on disposal should be added to the document. Include an estimated amount and kind of material, characterization of the material where it will be disposed and impacts on the disposal area. Also, include impacts of transportation to disposal area. A similar discussion on borrow should be added.

Response: A discussion on disposal and borrow materials and impacts of their transportation has been included in paragraphs 5.32 and 5.36 through 5.39.

10. Comment 10, page EIS-19, paragraphs 5.05 and 5.07 et al - References in these paragraphs are incorrect. Check and correct all references.

Response: The references have been corrected.

11. Comment 11, page EIS-21, paragraph 5.16 - The discussion in this paragraph is titled Aesthetic Values. It is assumed the effect discussed in the first sentence is a negative aesthetic effect. However, the second sentence notes the plant materials (which will partially offset impacts) will be selected primarily for their wildlife values.

Response: Paragraph 5.16, which discusses aesthetic values, has been rewritten to clarify the discussion on effects.

12. Comment 12, page EIS-21, paragraph 5.17 - Include an evaluation of the potential of locating archaelogical sites and an assessment of the project impacts to these resources.

Response: Paragraphs 5.19 and 5.20 include an evaluation of the potential of locating archeological sites and an assessment of the project impacts to these resources.

13. Comment 13, page EIS-22, paragraph 5.20 - What is the basis of the assumption that 30 older residents will give up their homes to move into a church-operated retirement home? Why would bearing full shares of the local cost bring hardship to the older residents of the neighborhood, specifically or exclusively?

Response: The city of Chaska informed the District of the possibility that older residents in the floodplain might sell their houses if required to bear full shares of the local costs. Some of these residents might choose to move to the church home but not necessarily all. Many of the floodplain residents in "Old" Chaska are senior citizens on fixed incomes who would presumably be faced with relatively more financial hardship if forced to bear full shares of local costs than younger residents.

14. Comments 14, page EIS-23, paragraph 5.27 - The discussion here appears inconsistent with the 21 February 1984 letter from the city of Chaska.

Response: Paragraph 5.30 (formerly 5.27) has been modified to reflect the city's support of the project.

15. Comment 15, page EIS-25, paragraph 5.30 - The discussion on T&E species should be expanded. In section 4 included a baseline description of T&E species under its own heading. In section 5, under T&E species heading, note the results as reported in paragraph 5.30.

Response: Discussions of T&E species have been included in paragraphs 4.18 and 5.17. We will complete coordination with the state on state listed species in time to insert the results into the DSEIS before public distribution.

16. Comment 16, page EIS-28, paragraph 6.07 - Each recommendation of the FWS under the FWCA should be specifically addressed in the EIS comment/response format. The last sentence in this paragraph is no longer correct.

Response: The last sentence in paragraph 6.07 has been modified. FWS recommendations made under FWCA and St. Paul District responses are included in paragraphs 53 through 76, pages 16 through 19, of the Phase II GDM and are referenced in the public participation section of the DSEIS.

17. Comment 17, General - The EIS should include an index, reference and appendix section per ER 200-2-2.

Response: The index page was not completed in time for the report to be sent to NCD. It is now included.

18. Comment 15, page 15, paragraph 50 - To be consistent with paragraph 6.05 (page EIS-27), the following statement should be added after the first sentence in paragraph 50: "Final supplement to the FEIS and the 404(b)(1) evaluation will be submitted to Congress under the provisions of Section 404 of the Clean Water Act." In order for this project to qualify as an FY 86 new construction start, the fully coordinated and approved FSEIS/404 evaluation would need to be submitted to OCE by February 1985.

Response: The sentence has been added in paragraph 50 as directed. Comment regarding scheduling of submittal of FSEIS/404(b)(1) evaluation to OCE is noted. Barring unforeseen contingencies, NCS expects to meet its schedule.

19. Comment 19, page EIS-35, d - The fill material for this project is reported here and elsewhere in the report to be clean or uncontaminated. The reasons for excluding some of the types of fill material from chemical and biological testing are readily apparent (although not specifically stated). However, some of the excavated material proposed for use as fill, e.g., impervious glacial till, cannot be as simply excluded from testing requirements. Evaluation and testing criteria in subpart G of the 404(b)(1) guidelines should be applied to the pertinent subsurface boring data and historical use data available for the extraction sites. If all of the material cannot be excluded from testing, either new material sources should be found or USEPA should be contacted regarding appropriate testing required.

Response: The "contaminant determinations" section of the 404(b)(1) evaluation has been rewritten.

TABLE OF CONTENTS

Tables

Plates

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8	M34-CH-9-5/41	Levee Improvements Plan & Profile	STA 85+00 to 94+00
9	M34-CH-9-5/42	Chaska Creek Plan & Profile	STA 12+00 to 28+00
10	M34-CH-9-5/43	Chaska Creek Plan & Profile	STA 28+00 to 41+00
11	M34-CH-9-5/44	Chaska Creek Plan & Profile	STA 41+00 to 55+00
12	M34-CH-9-5/45	Chaska Creek Plan & Profile	STA 55+00 to 68+00
13	M34-CH-9-5/46	Chaska Creek Plan & Profile	STA 68+00 to 69+00
14	M34-CH-9-5/55	Chaska Creek Service Road	
15	M34-CH-9-5/57	East Creek Levee Plan & Profile	STA 0+00 to 14+00
16	M34-CH-9-5/58	East Creek Levee Plan & Profile	STA 14+00 to 27+00
17	M34-CH-9-5/59	East Creek Levee Plan & Profile	STA 27+00 to 36+00
18	M34-CH-9-5/60	East Creek Levee Plan & Profile	STA 36+00 to 46+00
19	M34-CH-9-5/61	East Creek Channel Plan & Profile	STA 5+00 to 19+00
20	M34-CH-9-5/62	East Creek Channel Plan & Profile	STA 19+00 to 33+00
21	M34-CH-9-5/63	East Creek Channel Plan & Profile	STA 33+00 to 39+08
22	M34-CH-9-5/64	East Creek Channel Plan & Profile	STA 69+00 to 77+00
23	M34-CH-9-5/65	East Creek Channel Plan & Profile	STA 77+00 to 89+00
24	M34-CH-9-5/66	Outlet A	
25		Proposed Flood Plan Control	
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Appendixes

A - Hydrology and Hydraulics
B - Interior Flood Control
C - Geotechnical Design
D - Structural
E - Economics
F - Cost Estimate
G - Recreation Resources Development and Aesthetics
H - Local Cooperation Letters
I - Evaluation of Existing Levees

MINNESOTA RIVER AT
CHASKA, MINNESOTA
FLOOD CONTROL PROJECT

General Design Memorandum and
Draft Supplement II to the Final
Environmental Impact Statement

Design Memorandum Schedule

DM No.	Item	Scheduled Completion	Submittal NCD	Submittal OCE	Approved
-	Limited Reevaluation Report				Dec 82
-	General	Mar 84	Mar 84	May 84	Jul 84
1	Chaska Creek Diversion Channel	Jul 84			
2	East Creek Diversion Channel	Aug 85			
3	Minnesota River Levees, Interior Flood Control Features	Jul 86			

PERTINENT DATA

Project Document - House Document 94-644, 94th Congress, 2nd Session.

Project Authorization - 1976 Water Resources Development Act (Public Law 94-587).

Project Purpose - Flood Control.

Location - The project is located on the Minnesota River in Carver County and Chaska, Minnesota, and includes both Chaska and East Creeks, which are tributaries of the Minnesota River.

Hydrology and Hydraulics

Watershed Drainage Area	26.8 Square Miles
Design Flood Frequency	Standard Project Flood
Design Flows	
Chaska Creek Diversion	6,040 cfs
East Creek Diversion	6,200 cfs
Minnesota River	168,000 cfs

Principal Items of Work

Diversion Channel	7,100 LF
Channel Improvement	1,500 LF
Levee Improvement	5,800 LF
New Levee	7,800 LF
Cut and Cover Conduit, 16' X 16' Box	1,500 LF
Inlet Structures	2
Outlet Structures	2
Drop Structures	1
Pumping Station	1
Bridge Removals	2
Bridge Replacements	7

Economics

Federal First Cost	$19,710,000
Non-Federal First Cost	3,884,000
Total First Cost	23,594,000
Average Annual Operation & Maintenance Cost	43,000
Total Average Annual Cost	2,076,000
Average Annual Benefits	2,301,000
Benefit-Cost Ratio	1.11

AUTHORIZATION

1. The authority for this project is contained in Section 102 of the 1976 Water Resources Development Act (Public 94-587, House Document 94-644) which states:

"The following works of improvement for the benefit of navigation and the control of destructive floodwaters and other purposes are hereby adopted and authorized to be prosecuted by the Secretary of the Army, acting through the Chief of Engineers, substantially in accordance with the plans and subject to the conditions recommended by the Chief of Engineers in the respective reports hereinafter designated.

"The project for local flood protection and other purposes at Chaska, Minnesota, on the Minnesota River: Report of the Chief of Engineers dated May 12, 1976, at an estimated cost of 10,498,000."

2. Previous studies were done under the following authorizations:

Section 6 of the Flood Control Act of 22 June 1936:

"The Secretary of War is hereby authorized and directed to cause preliminary examinations and surveys for flood control at the following-named localities, . . . Minnesota River, Minnesota . . ."

A resolution adopted 10 May 1962 by the Committee on Public Works of the United States House of Representatives:

"Resolved by the Committee on Public Works of the House of Representatives, United States, That the Board of Engineers for Rivers and Harbors be, and is hereby, requested to review the report of the Chief of Engineers on the Minnesota River, Minnesota, published as House Document 230, 74th Congress, First Session and other pertinent reports, with a view to determining the advisability of further improvements in the Minnesota River Basin for navigation, flood control, recreation, low-flow augmentation, and other related water and land resources."

LOCATION OF PROJECT AND TRIBUTARY AREA

3. The city of Chaska is located in Carver County, Minnesota, on the left bank (north side) of the Minnesota River (mile 29.6) about 20 miles southwest of Minneapolis, Minnesota. Most of the developed portion of the city is located in the floodplain. At Chaska, the Minnesota River drains an area of about 16,600 square miles. Chaska Creek (also referred to as West Chaska Creek, or West Creek) has a drainage area of about 15 square miles and flows through the west end of the city. An unnamed creek (sometimes referred to as East Chaska Creek or East Creek) with a drainage area of about 11.8 square miles flows through the northeast side of the city. For purposes of this

report, the latter stream is referred to as East Creek. Both streams generally flow in a southeasterly direction prior to entering the Minnesota River, which flows easterly to its confluence with the Mississippi River.

4. The drainage basin of the Minnesota River upstream from Chaska is a gently undulating prairie region at elevations between 700 and 1500 feet above sea level. Floodplain areas at Chaska begin at elevation 705 and average about a mile in width at elevation 730 on the Minnesota River. Much of this area consists of marshes or lakes. The main part of the city of Chaska is situated between elevation 710 and 730. An alluvial terrace rises above the older part of Chaska and the Minnesota River floodplain to form a prominent bench at about elevation 750. From this terrace, the river valley walls rise steeply to form a bluff, generally at elevations between 850 and 900. Upland areas (elevations 850 to 1070) range from poorly drained marshy areas in the Chaska Creek watershed to rolling hills in the East Creek drainage area. Both creeks flow through deep, steep-walled valleys about a mile long before emerging onto the terraced area of the Minnesota River Valley. Two natural lakes, Lake Bavaria (201 acres) and Hazeltine Lake (236 acres), lie in the extreme headwaters of the East Creek watershed. Chaska Creek watershed has numerous marsh-type impoundments but no large lakes. Two abandoned clay pits filled by ground water serve as park areas in the developed part of Chaska.

HYDROLOGY

GENERAL

5. The basic hydrologic studies for Chaska were reported in appendix 4 of the limited reevaluation report, August 1982. These studies included descriptions of the watershed characteristics and climate, the storm characteristics of the basin, and the watershed model used to develop runoff hydrographs for synthetic floods and hypothetical floods. They also provided an estimate of the probable maximum flood and standard project flood and an analysis of the flood frequency curves. A brief summary of these studies follows.

CLIMATE

6. The climate of Chaska and its vicinity is moderate, characterized by wide variations in temperature, normally sufficient rainfall for crops, and moderate snowfall. The mean annual temperature at Chaska is 44° F. The mean monthly temperature varies from 12° F in January to 72° F in July. Annual precipitation averages 26 inches, and average annual snowfall is 44 inches.

WATERSHED MODEL

7. The hydrologic analysis of the basin was conducted using the Hydrologic Engineering Center's HEC-1 computer program. The model developed for this study evaluates the storm water runoff for both the Chaska

Creek and East Creek watersheds. The Chaska Creek watershed was divided into nine subwatersheds varying in size from 0.44 to 3.04 square miles. The drainage area of Chaska Creek was determined to be 14.91 square miles. The drainage area of East Creek's watershed was determined to be 11.83 square miles. It was divided into 11 subwatersheds ranging in size from 0.49 to 2.36 square miles.

FLOOD FREQUENCY CURVES

8. Because there were no discharge records for either Chaska Creek or East Creek, the HEC-1 Flood Hydrograph package computer program was used to model both existing and future conditions and to determine flood frequency curves. An elevation-frequency curve for the Minnesota River at Chaska was derived using HEC-2 backwater computations completed by the U.S. Geological Survey and verified by St. Paul District. Detailed information on these curves is contained in the reference cited above and in appendix A of this report.

STANDARD PROJECT FLOODS

9. The standard project flood (SPF) for the Minnesota River at Chaska was derived from a previously determined SPF for the Minnesota River near Carver. The SPFs for the Chaska Creek and East Creek watersheds were determined using the HEC-1 model. Details of these determinations are also contained in the reference cited above.

GEOTECHNICAL

10. The region surrounding the project area was glaciated extensively during the Pleistocene Epoch. The glaciers laid down thick deposits of outwash sands and unsorted tills that today form a hummocky, poorly-drained plain dotted with marshes and small lakes. The glacial drift reaches a thickness of 200 to 250 feet and rests on dolomitic limestone and sandstone of the Prairie du Chien and Jordan Formations. The large valley of the present Minnesota River was carved by the glacial River Warren, which carried large volumes of water discharging from the now-extinct glacial Lake Agassiz located in western Minnesota and eastern North Dakota. This river cut deeply into bedrock and formed the terraces that are prominent today. As the flows decreased, the valley was filled to its present level with alluvial sand, silt, and soft clay.

11. The alluvial sediments under the existing levee consist primarily of fine and medium sand. Boring 73-1M, located near the midpoint of the levee, ended in the sand at a depth of 152 feet. Silt and clay are the dominant surficial materials under the proposed levee extension. Boring 73-3M, located in this area, penetrated 58 feet of silt and clay and ended in silty fine sand at a depth of 62 feet. Bedrock, which underlies the floodplain at a depth greater than 150 feet, is expected to be sandstone of the Franconia and Dresbach Formations. The broad

floodplain and lower terrace levels are frequently flooded, poorly-drained, and characterized by a high water table. A detailed discussion of the geotechnical aspects of this project is contained in appendix C of this report. Subsurface explorations, stability analyses, and discussions concerning all elements of geotechnical design can also be found in appendix C.

DESCRIPTION OF THE AUTHORIZED PROJECT

12. The major features of the project as authorized by the 1976 Water Resources Act include upgrading the city-owned levee, diverting portions of two area creek channels, regulating the floodplain, and developing recreational trails.

MINNESOTA RIVER LEVEE IMPROVEMENTS

13. The levee built by the city would be improved and extended to protect Chaska from Minnesota River flooding. The principal features of the work are:

- About 6,000 feet of upgraded levee (city levee).
- About 3,000 feet of new levee.
- Four ponding areas with related pumping capacity.
- About 4,150 feet of storm water interceptor sewers.
- A seepage relief well system for the levee.

EAST CREEK DIVERSION

14. The proposed channel would divert flood flows around the east side of the city directly to the Minnesota River. Under normal flow conditions, water would continue to flow through the existing East Creek channel.

CHASKA CREEK DIVERSION

15. The proposed Chaska Creek diversion channel would carry Chaska Creek floodwaters through an industrial zone on the west side of Chaska to the Minnesota River floodplain. The existing channel downstream of the diversion would carry local runoff but would not carry upstream runoff.

FLOODPLAIN REGULATION

16. Ponding areas and remaining unprotected portions of the river and creek floodplains would be subject to floodplain regulation to control flood-related damage to future development.

RECREATION

17. The authorized project calls for about 1 1/2 miles of paved recreation trails on top of the levee and around Courthouse Lake. These trails would complement the open-space stream corridor system being considered by Chaska and could be connected to the Minnesota River Valley trail system being developed by the State.

PROPOSED STRUCTURES AND IMPROVEMENTS

GENERAL

18. As a result of continued analysis and design efforts, the authorized plan has been revised. The proposed plan is described in the following paragraph. Basically, the principal structural flood protection measures for Chaska include 7,100 feet of diversion channel on Chaska Creek; 1,500 feet of channel and channel improvement, 4,600 feet of low levee, and 1,500 feet of cut and cover conduit on East Creek; 5,800 feet of upgraded levee, 3,200 feet of new levee, and a pumping station. The proposed plan also includes 1.6 miles of paved recreation trails on top of the levee and around Courthouse Lake.

CHANNELS

19. The Chaska Creek diversion channel starts north of Highway 212 and carries flows around the west side of the city outside of the levee to a point south of Spruce Street. There it reenters the natural channel to the Minnesota River. This channel consists of an ogee spillway inlet structure approximately 35 feet wide and 200 feet long that empties into a rectangular, reinforced concrete supercritical flow channel. The outlet structure is a preformed, riprapped scour hole which is 75 feet wide, 300 feet long, and about 12 feet deep at its deepest point. (Note: All dimensions cited in this section are approximations.)

20. The East Creek channel consists of a 70-foot-wide drop structure upstream of Brandon Boulevard. About 1,500 feet (to Engler Boulevard) of the existing channel would then be modified to a concrete rectangular channel with a 50-foot bottom width. Between Engler Boulevard and Crosstown Boulevard, the channel would not be modified, but would take advantage of the natural channel to retard flow and dissipate energy. To contain the flows within the natural channel, a levee would be constructed along the edge of the greenway on the south side of the existing channel. This levee would have a maximum height of 9 feet and an average height of 7 feet, and would be 4,600 feet long.

21. The flood flows would be diverted by means of an inlet structure into a 16' X 16' foot concrete box culvert. This would convey the flows southeast under Crosstown Boulevard to beyond Bierline Avenue. The culvert would empty into a 300-foot section of riprapped channel

and then continue in a trapezoidal grasslined channel having a 94-foot bottom width and 1 vertical on 3 horizontal side slopes. The channel would terminate in a concrete outlet structure located near the natural mouth of East Creek. Because the concept for the East Creek diversion was changed by a Value Engineering study in January 1984, the details of the above design are subject to change. The following items will be studied during preparation of the feature design memorandum to determine the most cost effective final design: the size and construction of the cut and cover conduit, the location of the inlet structure, the size of the channel improvement between the inlet near Brandon Boulevard and Engler Boulevard, and the type and location of the outlet. Additionally, the entire downstream end of the diversion will be studied to determine the best way of minimizing impacts on the environment in that area.

LEVEES

22. The Minnesota River levee system along the west and south sides of the city would be raised approximately 3 feet to elevation 728.0, and the side slopes would be flattened to conform to current design standards. A new levee, constructed to the same standards, would begin about where the old levee ends and will carry around Courthouse Lake for a distance of approximately 3,200 feet. The East Creek levee system would extend along the south side of the natural channel between Engler and Crosstown Boulevards. It would be about 7 feet high and 4,600 feet long.

23. The outlet structure in the Minnesota River levee system would consist of two 108-inch reinforced concrete pipes (RCP) and a gatewell and sluice gates. The East Creek levee system would have the outlet structure described above for flood flows and a 48-inch reinforced concrete pipe to carry the normal flows through the levee. This pipe would be equipped with a sluice gate to allow regulation of the flow in the natural channel during floods.

PUMPING STATION

24. A pumping station having a capacity of 21,700 gallons per minute would be located at the south end of Pine Street. Two ponding areas have been designated to provide storage for interior flood control. One is located in Section 1, and consists of the portion of the existing Chaska Creek channel (1.5 acres) that lies inside the levee system. The other is 17.8 acres in Section 4, northeast of Courthouse Lake.

BRIDGES

25. Six bridges would have to be altered for the project. Four of these are crossings over the Chaska Creek diversion channel. The first is at Hillside Drive, and alterations would consist of a reinforced concrete bridge deck with abutments designed integrally with the channel wall. It would be 40 feet long and 24 feet wide. The second bridge is at Hickory Street and is of the same design. The third

bridge is at First Street, and it would be 43 feet long and 32 feet wide. A steel girder railroad bridge would be reconstructed near First Street. It would be about 80 feet long and 12 feet wide. An abandoned timber trestle railroad bridge near Highway 212 would be removed and not replaced.

26. The culverts at the Highway 41 junction with East Creek would be replaced with a 40-foot-long by 32-foot-wide bridge. The bridge over East Creek at Brandon Boulevard would be 50 feet long and 24 feet wide. A bridge measuring 50 feet long by 32 feet wide would replace two 10-foot RCPs at Engler Boulevard. The steel girder bridge over East Creek at Crosstown Boulevard would be removed and replaced with the 48-inch RCP previously mentioned in the Levees Section.

OTHER FEATURES

27. Recreational improvements would be made as outlined in appendix G of this report. Improvements which are part of the environmental mitigation plan are discussed in draft supplement II to the final EIS, which is also contained in this report.

DEPARTURES FROM AUTHORIZED PLAN

MINNESOTA RIVER LEVEE IMPROVEMENTS

28. Only two ponding areas are to be designated, instead of four as originally proposed. In the authorized plan, a 23,800-gpm pumping station was proposed at the Chaska Creek outlet, a 56,000-gpm pumping station at Elm Street, a 59,200-gpm pumping station at Maple Street, and an 84,000-gpm pumping station at the East Creek outlet. The design capacities of the four pumping stations were based on the peak discharge from a coincidental rainfall with a 2.5-year recurrence interval. A detailed probabilistic analysis was performed and revealed that pumping stations are not economically justified at any location. However, because of seepage accumulation problems along the Minnesota River, one 21,700-gpm pumping station is recommended at Pine Street. Additionally, the amount of interceptor sewer can be reduced from 4,150 to 3,570 linear feet.

EAST CREEK DIVERSION

29. A combination of earth channel, a low levee system between Engler Boulevard and Crosstown Boulevard, and a 16-foot by 16-foot cut and cover concrete box culvert will replace the authorized plan's riprap channel. This alternative would eliminate the need to relocate the trailer park. It would also replace three bridges included in the authorized plan with bridges at Brandon Boulevard and Engler Boulevard. The new system has several advantages:

a. It involves fewer conflicts with future expansion of transportation and industrial development.

b. It provides flood protection for a greater portion of the urban area by reducing the size of the residual flood plain.

c. It substantially reduces the number of residential relocations.

d. It reduces total real estate acquisition requirements.

CHASKA CREEK DIVERSION

30. A rectangular concrete supercritical flow channel will replace the trapezoidal channel in the authorized plan for the following reasons:

a. It substantially reduces the amount of excavation required and the number of residential relocations.

b. It eliminates the need to replace the Highway 212 bridge.

c. It eliminates several utility relocations.

d. It reduces the construction costs.

INTERIOR FLOOD CONTROL

31. The proposed interior flood control plan at Chaska includes four gravity outlets through the proposed levee at the mouth of Chaska Creek, at Pine Street and Ash Street, and at the mouth of East Creek; one interior culvert from Courthouse Lake to the existing East Creek channel; a storm water interceptor sewer about 3,750 feet long from just west of Spruce Street to Maple Street; and a 21,700-gpm pumping station at Pine Street. Design details for the gravity outlet, storm water interceptor sewer, and the pumping station are in appendix B of this report.

ALTERNATE PLANS INVESTIGATED

32. The 1973 feasibility report and the 1982 limited reevaluation report have provided the project formulation. Authorized for construction by the 1976 Water Resources Development Act on the basis of the feasibility report, the project had, and still maintains, a very strong backing from local sponsors and their Congressional representatives. No significant objections were ever made to this flood control project, although several agencies commented on project feature designs or requested that general environmental concerns be acknowledged during construction.

33. The limited reevaluation report recommended a subcritical flow design for the Chaska Creek channel and an alignment for the East Creek

diversion channel which lies east of the city of Chaska and passes through the corporate boundaries of the city of Chanhassen, Minnesota. Two Value Engineering (VE) studies were done during late 1983 and early 1984. The Chaska Creek VE study recommended a change from subcritical flow design to supercritical flow design. The East Creek VE study recommended realignment of the diversion channel to divert flows under Crosstown Boulevard using a low levee system and cut and cover conduit. Both proposals were approved by the St. Paul District Engineer and were coordinated with the city of Chaska, which expressed its strong support for the proposals in an undated letter received on 20 January 1984.

CONSTRUCTION MATERIALS

GENERAL

34. Much of the berm and embankment material required for the projec would be generated by excavation of the flood storage area. Th remainder of construction materials required could be acquired fros commercial sources in the area.

RIPRAP AND BEDDING

35. Riprap and bedding of adequate quality could be obtained from limestone quarries in the Prairie du Chien formation located on the south side of the Minnesota River Valley within 10 miles of Chaska.

CONCRETE AGGREGATE

36. Concrete aggregate of adequate quality could be obtained from continuously operating sources of natural aggregate and crushed rock in the Minneapolis-St. Paul metropolitan area, 25 to 50 miles from the project site. Sources located within 10 miles of Chaska exist, but produce concrete aggregate only on an intermittent basis. Although these closer sources have not been tested or used for Corps of Engineer projects, information obtained from the Minnesota Department of Highways indicates their material would be adequate as a concrete aggregate.

LEVEE FILL

37. Levee fill would consist of impervious glacial till obtained from the diversion and bypass channel excavations. A plentiful supply of this material is available from the surrounding uplands if sufficient quantities are not obtainable from channel excavations.

ACCESS ROADS

38. Public roads would be used for access to project construction sites. U.S., State, county, and city roadways provide access to all project areas. Most of these roads are well maintained and capable of accommodating the transportation of construction equipment and materials. City streets are generally adequate for transportation to

project areas. It is possible to route heavy or oversized loads around bridges or other structures with limited capacity. Access can be gained to each construction site by more than one route. No new roads except for short, temporary construction access off existing public roadways would be necessary, and these areas would be restored to their original condition upon completion of construction.

39. The most significant diversion problem would occur during the construction of the Chaska Creek diversion channel. The channel would be constructed in phases, starting with the outlet and moving upstream to the Highway 212 bridge. In this reach, the channel generally lies outside the natural streambed. At points where it does conflict, the normal flows (approximately 1 cfs) could be diverted using either temporary ditching or piping. Once this reach is constructed, a small cofferdam could be built just upstream of the inlet structure. A pond would be allowed to form and normal flows would be pumped through a 24-inch pipeline around the construction site, under the Highway 212 Bridge, and into the newly constructed channel. Care would be taken to lay out the construction site so as to allow free flow through the site in the event of a flash flood.

40. The only diversion problem on the East Creek alignment would be solved by constructing the inlet structure at one side at a time.

REAL ESTATE

41. The proposed project would require the local sponsor to acquire perpetual and temporary easements on approximately 144.7 acres. The estimated acreages and estates are: 49.9 acres - perpetual flood protection levee easement; 11.4 acres - perpetual easement for a diversion channel; 6 acres - perpetual easement for a cut and cover conduit; 13.5 acres - perpetual channel improvement easement; 19.3 acres - perpetual flowage easement to occasionally overflow; and 50 acres - temporary work area and access easement. No additional lands are to be acquired for recreation, mitigation, or beautification. About 1.6 miles of lands acquired for levees will also be used for a recreation trail. The local sponsor must either acquire those lands in fee or additional easement rights for the trail. Existing Federal wildlife refuge land will be used for fish and wildlife mitigation. This action is supported by the Minnesota Department of Natural Resources and the U.S. Fish and Wildlife Service. All plantings, landscaping, and beautification referred to elsewhere in this report will be done on the lands being acquired in perpetual easement for other project purposes identified above.

42. It is estimated that the project will affect 67 ownerships and cause the displacement of 7 residences. In addition, 10 garages and 1 business structure will be acquired. Lands affected include undeveloped open areas and residential, commercial, and park lands. The estimated costs of acquiring the rights-of-way are as follows:

94.7 acres - perpetual easements for levees, channel improvements and diversion, cut and cover conduit, and flowage easement		$600,000
50.0 acres - temporary work area and access easement		140,000
Improvements		500,000
Contingencies (20%±)		250,000
PL 91-646 Relocation Payments		70,000
Administrative		140,000
	TOTAL	$1,700,000

RELOCATIONS

RAILROAD RELOCATIONS

43. The Chicago Northwestern line which runs along Highway 212 would have to be temporarily relocated at its intersection with the Chaska Creek diversion during construction of the bridge over that channel. This would be done by constructing a bypass spur adjacent to the existing tracks. The same line would also require temporary relocation at its intersection with the East Creek diversion channel during construction of the cut and cover culvert. This also would be done using a bypass spur, as would temporary access to the railyard at the sugar factory. Discussions with the Chicago Northwestern Transportation Company indicate that the line in question is currently under study to determine its ultimate use. The railroad is analyzing three alternatives: abandonment, minimum usage, and maximum usage. If abandonment is selected, only the sugar factory access relocation would be required. If minimum usage is selected, it may become economically feasible to pay detour costs to the railroad rather than provide the necessary relocations. All the relocations described above would be required if the maximum usage option is selected.

ROAD RELOCATIONS

44. New bridges would be constructed at Hillside Drive, Hickory Street, First Street, Brandon Boulevard, Engler Boulevard, and State Highway 41. The bridge over East Creek at Crosstown Boulevard would be replaced with a 48-inch RCP. Details about these structures are contained in appendix D of this report. Preliminary coordination with appropriate agencies has been made. Final coordination will be made as final details become known.

TEMPORARY ROUTING OF TRAFFIC

45. The new bridges at Hillside Drive and Brandon Boulevard would be constructed before the existing ones are removed. All other bridge replacements would involve detouring traffic by use of other streets and roads in the area. Additionally, care would be taken to ensure that the bridge at Engler Boulevard is completed before work on Crosstown Boulevard begins, because Crosstown will act as the detour route for Engler and vice versa. The same applies to First and Hickory Streets and Highway 212 and Stoughton Avenue. Detour routes and distances are shown in the table below.

Table 1
Summary of Detour Routes

Road	Detour Route	Detour Distance (Miles)
Hickory Street	First Street	0.50
First Street	Hickory Street	0.50
Engler Boulevard	Crosstown Blvd.	1.92
Crosstown Boulevard	Engler Blvd.	1.92
State Highway 41	County Road 11	3.69
State Highway 212	Stoughton Avenue	1.00
Stoughton Avenue	Highway 212	1.00

UTILITY RELOCATIONS

46. Preliminary alteration/relocation plans are being made for telephone and power companies which own facilities within the project area. Approximately 0.38 miles of underground line and 2.27 miles of overhead line are scheduled for alteration/relocation. Approximately 0.55 miles of sanitary and storm sewer lines and 0.64 miles of water line must also be altered or relocated. Coordination has been made with the local sponsor to determine their plans for future expansion of their sewer and water system. As a result, the Chaska Creek diversion channel has been designed so that it does not interfere with a sewer expansion project in the Hillside subdivision which will be constructed during the summer of 1984. Additionally, the Chaska city engineer is analyzing a planned sewer expansion on Crosstown Boulevard to determine if it can be incorporated into the project excavation.

ENVIRONMENTAL

47. After completion of the limited reevaluation report and final supplement I to the final environmental impact statement (FEIS) in August 1982, a number of project components were modified, added, or deleted. Deletions included the East Creek trapezoidal flood bypass channel and tunnel, the replacement of the Highway 212 bridge, and the construction of the County Road 17 bridge. All these were deleted as a result of the value engineering studies. The major modifications include narrowing the Chaska Creek diversion channel, extending the Chaska Creek inlet structure, and reducing the Minnesota River levee outlet structure from three to two 108-inch RCPs. The additions consist mainly of the East Creek changes described in the Proposed Improvements Section of this report.

48. With the exception of the East Creek VE proposal and the need for four additional permanent residential relocations necessary for other project features, these changes would not have a significant cumulative impact on the social, cultural, and natural resources of the project area over and above the impacts of the entire project as evaluated in the phase 1 limited reevaluation report. The East Creek VE proposal would have significant impacts on the following resources: floodplain forests, East Creek riparian and aquatic ecosystem, floodplain

wetland/old field habitat, prime farmland, water quality, recreational resources, aesthetic values, neighborhood stability, community cohesion, and community fiscal soundness. Also, the East Creek feature creates a conflict with Executive Order 11988 on Floodplain Management because it would induce development in a floodplain. However, an analysis of the feature was done in light of EO 11988 and it was found that there is no practicable alternative because all possible alignments for the the East Creek diversion would remove the land in question from the floodplain. The East Creek feature and its impacts are discussed in detail in draft supplement II to the FEIS, contained in this GDM. Final Supplement II to the FEIS and the 404(b)(1) evaluation will be submitted to Congress under the provisions of Section 404(r) of the Clean Water Act.

49. Placement of fill material into the aquatic environment would result in both temporary and permanent losses of aquatic habitat. However, using clean fill, placing temporary levees around some construction sites, and conducting construction activities during low-flow periods and incorporating erosion reduction measures during construction should minimize the potential for adverse impacts.

50. The changes in the East Creek feature and the effects of placing fill material into the aquatic habitat are discussed more fully in draft supplement II to the FEIS and in the Preliminary Section 404(b)(1) evaluation contained in this GDM. A 404 (b)(1) evaluation addressing fill impacts of the entire project was part of supplement I to the FEIS, which was submitted to Congress in 1983 under Section 404(r) requirements.

FISH AND WILDLIFE CONSIDERATION

GENERAL

51. Project-induced impacts on fish and wildlife resources were evaluated using the habitat evaluation procedures (HEP) analysis conducted by a team of biologists from the U.S. Fish and Wildlife Service, the Minnesota Department of Natural Resources, and the Corps of Engineers. This method was applicable to resource evaluation for the Chaska flood control study, and it served as a useful tool for ranking the relative habitat impacts of various structural alternatives. The HEP analysis was supplemented with a habitat area replacement analysis. The concept behind this analysis is that acres of affected habitat are replaced in-kind by equal acres of the same habitat types. A total of about 40 acres of significant habitat, excluding croplands and "urban grasslands," would be affected by the Chaska flood control project structures. The recommended mitigation plan, supported by both the HEP and habitat area replacement analysis, indicates that wildlife plantings on project lands plus development and management on the existing Federal wildlife refuge would provide adequate compensation for adverse impacts on significant fish and wildlife resources.

52. The proposed mitigation feature is supported by the Minnesota Department of Natural Resources and the U.S. Fish and Wildlife Service. It complies with both Fish and Wildlife Service and Corps of Engineers mitigation policies because it would be implemented on Federal land immediately adjacent to the project area, because Chaska residents would be the primary users and beneficiaries of the mitigation features, because it would provide equal replacement of opportunities for nonconsumptive uses of wildlife resources reduced by the proposed project, and because the proposed plan would provide habitat for many of the same wildlife species as those affected by the Chaska project. Although the mitigation proposal would achieve sufficient replacement of the values of habitat adversely affected by the proposed project, the habitat would not be completely replaced in-kind. The goal of providing in-kind habitat replacement could not be achieved because of limitations on land acquisition, lack of efficiency and implementability of intensive habitat management measures, and the possibility of achieving results of greater overall habitat value by executing the proposed mitigation plan.

MANAGEMENT RECOMMENDATIONS FOR PROJECT LANDS

East Creek Levee

53. Recommendation 1 - The levee would offer little opportunity for habitat improvement with future maintenance practices such as mowing, the use of herbicides, and planting limitations. However, the Service recommends the levee be seeded with legumes and grasses following construction. Levee maintenance practices should be avoided or minimized to improve habitat for wildlife use.

54. Response - The planting plan for the levee will include seeding with a variety of legumes and grasses. Mowing and other maintenance activities will have to be done to maintain the structural integrity of the levee, but will be kept to a minimum to the extent possible.

55. Recommendation 2 - Areas within the channel proper should be seeded with grasses and legumes. Vegetation should be allowed to grow to the maximum height possible under maintenance restrictions.

56. Response - The planting plan for the channels will include seeding with a variety of grasses and legumes. Mowing and other maintenance activities will have to be done to maintain the structural integrity of the channels, but will be kept to a minimum to the extent possible.

57. Recommendation 3 - Shrubs such as willow and dogwood should be planted along the top of the channel banks. A variety of native tree species such as wild plum, choke cherry, cottonwood, and maple should be planted in areas consistent with channel maintenance restrictions. Plantings of small conifers are also recommended to provide winter cover.

58. Response - The planting plan for the channel bank areas will include species the same as or similar to those listed above. These woody plantings will be limited to areas not needed to convey the design flood and within the project right-of-way. They will not be allowed to spread into the channel area and will be consistent with the other channel maintenance requirements.

59. Recommendation 4 - Mowing and use of herbicides for channel maintenance purposes should be avoided or minimized to improve channel habitat for wildlife use. If necessary, a barbed wire fence should be installed along the outer edge of the right-of-way to protect the habitat from grazing or other agricultural disturbances.

60. Response - Herbicides would normally only be used for problem situations requiring control of noxious weeds or woody invader species. Mowing in channels will be kept to a minimum as long as the structural integrity of the project can be maintained. Barbed wire fencing will not be used near any urban areas. In agricultural areas, this type of fence may be used if habitat or the structural integrity of the project features is threatened.

Concrete Channel

61. Recommendation 5 - The proposed design of the concrete and riprap channel for portions of the revised East Creek diversion offers little opportunity for habitat improvement. However, the Service recommends plantings of native shrubs and small conifers along the channel banks to improve wildlife use and provide winter cover.

62. Response - The planting plan described in recommendation 3 will be undertaken wherever possible along the East Creek diversion channel.

Planted Uplands

63. One area along East Creek about 0.2 acre in size offers the opportunity to improve project lands for wildlife use. There are no limitations placed on management recommendations because these lands require no maintenance from a structural standpoint. For this area of planted uplands, the following habitat improvement measures are recommended:

64. Recommendation 6 - Shrubs and shrubby tree species such as dogwood, hazel, and Russian olive should be planted in this area. A variety of native tree species such as oak, wild plum, choke cherry, maple, and ash should also be planted. Plantings of small conifers are recommended to provide winter cover.

65. Response - The planting plan for the upland areas will include the species recommended above. They will not be allowed to spread into the areas needed to convey the design flood, and they will have to be consistent with the maintenance requirements of other project features.

66. Recommendation 7 - The area described above should be maintained and managed for wildlife purposes.

67. Response - These areas will be maintained and managed for wildlife purposes consistent with project feature maintenance requirements.

COMPENSATION RECOMMENDATIONS

68. The U.S. Fish and Wildlife Service evaluation required under the Fish and Wildlife Coordination Act resulted in four compensation recommendations. These recommendations are intended to supplement those contained in the final FWCA report with implementation of the proposed mitigation feature as an integral part of the Chaska flood control project.

69. Recommendation 1 - The Fish and Wildlife Service recommends the revised East Creek diversion channel be reduced in scope to avoid and minimize impacts on valuable habitat.

70. Response - As previously stated in this report, the concept for the East Creek diversion was changed by a Value Engineering study in January. Therefore, the details of the design are subject to change. The following items will be studied during preparation of the feature design memorandum to determine the most cost effective final design: the size and construction of the cut and cover conduit, the location of the inlet structure, the size of the channel improvement between the inlet near Brandon Boulevard and Engler Boulevard, and the type and location of the outlet. Additionally, the entire diversion will be studied to determine the best way of minimizing impacts on the environment.

71. Recommendation 2 - Maps showing lands necessary for construction and operation and maintenance of the project would be useful in identifying those lands which could be improved for wildlife uses; resulting gains in habitat values could be used to further reduce project impacts. For example, cropland or grassland areas adjacent to the levee and diversion channel which are necessary for project purposes may also be available for habitat improvement measures. If enough acreage were involved, resulting habitat gains could reduce project impacts to the point of compensating for remaining habitat losses associated with the revised project. The Service therefore recommends that such lands be identified by the District and that maximum measures be taken to improve habitat on these lands. This information should also be provided to the Service so the final habitat evaluation can be adjusted to incorporate any such habitat gains.

72. Response - Concur. Once the final decision on recommendation 1 is reached, this information will be provided.

73. Recommendation 3 - If a substantial net loss in habitat units continues to occur for the revised Chaska flood control project beyond action taken by the St. Paul District with respect to recommendations 1

and 2 above, the Fish and Wildlife Service recommends these losses be adequately compensated through additional habitat improvement measures.

74. Response - Again, the analysis which will be conducted for recommendation 2 must necessarily consider requirements for compensation for habitat losses. The plan will identify project land requirements and attempt to compensate for any additional habitat losses through habitat improvement on uneconomical project remnants. If this is not possible, other options will be explored, such as an additional compensation plan on the Minnesota Valley National Wildlife Refuge.

75. Recommendation 4 - This report assumes that only 3.1 acres of shallow marsh will be affected by construction of the revised East Creek diversion channel. However, because the channel will effectively bisect this habitat, secondary impacts associated with wetland drainage are possible. The St. Paul District should determine the extent of any such wetland drainage associated with construction of the proposed channel through wetland habitat. This information should be provided to the Service for incorporation into the final supplemental report.

76. Response - Concur. This determination will be made during the analysis of foundation conditions, and the information will be given to the Fish and Wildlife Service as it becomes available.

CULTURAL RESOURCES

77. Eight structures and one historic district are presently included on the National Register of Historic Places for Chaska, Minnesota. Fourteen additional historic structures in Chaska were identified in a 1978 survey conducted by the Minnesota State Historic Preservation Office for Carver County. A number of prehistoric burial mound groups are also reported for the Chaska area. One of these groups is within the historic district.

78. A cultural resources survey has been conducted for portions of the Chaska project area. No sites have been identified which will be affected by the proposed project. A more detailed description of the cultural resources in the project area, the impacts upon these resources, and future study needs can be found in draft supplement II to the final environmental impact statement.

RECREATION AND AESTHETICS

GENERAL

79. A full analysis of recreation and aesthetics was conducted as part of the August 1982 limited reevaluation report. That evaluation is still considered to accurately reflect local conditions. It recommended that the project include a trail system along the top of the levee and beautification by incorporating overburden areas and natural vegetation. The levee would be seeded to native prairie grass species.

RECREATION

80. An 8-foot-wide asphalt path would be built along the top of the levee and would extend from the western edge of the Chaska levee to Courthouse Lake, then continue around the Lake and tie into high ground a few hundred yards beyond. The existing levee would connect with the proposed levee, providing usable space for recreational activities. Chaska could easily maintain picnic grounds at Courthouse Lake as an area for passive recreational pursuits. An overburden area, which would not affect the structural integrity of the levee, would be constructed to allow native floodplain vegetation to grow up the sides of the levee and create a natural-appearing site conducive to birding, walking and other activities.

81. Paving the trail would encourage bicycle traffic and would hopefully alleviate the present congestion and conflict between automobiles and bicycles in Chaska. Courthouse Lake would serve as a city park, and people could take lunches on their bicycles and ride to the park. There is ample parking near the lake, which would encourage people to drive there and then bicycle around the lake or to other nearby areas. The paved pathway around the lake would also encourage use by handicapped people, including those confined to wheelchairs. A thorough analysis of access requirements for handicapped people to the entire project will be conducted during the FDM.

LANDSCAPING AND BEAUTIFICATION MEASURES

82. Implementation of the proposed flood control measures would involve considerable excavation and embankments in and through the urban area of Chaska. Such construction unavoidably affects vegetation in the area. The loss of vegetation would have varying degrees of adverse visual impacts on the community. To offset these impacts and thereby make the Chaska project more socially and environmentally acceptable, beautification measures such as landscaping and the aesthetically compatible design of structures and protective features are proposed as an integral part of the overall project. See appendix G for details of the beautification plan.

COST ESTIMATE

BASIS OF ESTIMATES

83. This estimate of costs is based on October 1983 price levels and, wherever possible, reflects recent prices for similar work in the St. Paul District. A summary comparison of project costs between the current approved estimate (PB-3, 31 March 1983) and the revised estimate prepared for this design memorandum is shown in table 2. Details of the revised cost estimate can be found in appendix F.

Table 2
Summary of Estimated First Costs ($000)

Item	Current Approved Estimate (PB-3, 31 Mar 83)	GDM Estimate
Federal First Costs and Non-Federal Contributions		
Relocations	218.0	410.0
Fish and Wildlife Facilities	144.0	133.0
Channels	10,963.0	12,425.0
Levees	3,541.0	3,081.0
Pumping Plants	283.0	480.0
Recreation Facilities	69.0	69.0
Engineering and Design*	1,875.0	1,992.0
Supervision and Administration*	1,049.0	1,162.0
Supervision and Inspection	(710.0)	(790.0)
Overhead	(339.0)	(372.0)
Total Cost (Federal First Costs & Non-Federal Contributions)	18,142.0	19,752.0
Non-Federal Contributions	42.0	42.0
Total Federal First Costs (Not including other non-Federal Contributions)	18,100.0	19,710.0
Non-Federal First Costs		
Lands and Damages	1,810.0	1,700.0
Relocations	1,458.0	2,142.0
Cash Contribution	42.0	42.0
(Recreation)	3,310.0	3,884.0
Total Non-Federal First Costs	3,310.0	3,884.0
Total Project First Costs	21,410.0	23,594.0

*Includes $15,000 for E & D and S & A for recreation facilities. Total cost for recreation facilities = $84,000.

84. The difference in Federal first costs, not including cash contributions (an increase of $2,184,000 between this design memorandum cost estimate ($23,594,000) and the current approved estimate from PB-3 effective October 1984 ($21,410,000)), is attributable to the following:

a. Relocations +192,000

(1) Increase due to addition of railroad relocations (+180,000)

(2) Increase due to refinement of railroad bridge construction estimate (+ 12,000)

b. Fish and Wildlife Facilities $ - 11,000

Decrease due to refinement of design estimate (- 11,000)

c. Channels $ +1,462,000

(1) Increase due to addition of Hickory Street drainage channel (+321,000)

(2) Increase due to addition of Chaska Creek service road (+40,000)

(3) Decrease due to redesign of Chaska Creek diversion from subcritical to supercritical flow (-198,000)

(4) Increase due to redesign of East Creek Diversion (+1,299,000)

d. Levees $-460,000

(1) Decrease due to refinement of design and cost estimate of levee (-205,000)

(2) Decrease due to elimination of closure on abandoned Milwaukee Railroad (-65,000)

(3) Decrease due to refinement of design and cost estimate for drainage facilities (-179,000)

(4) Decrease due to refinement of design and cost estimate of relief well system (-11,000)

e. Pumping Plant $+197,000

Increase due to increase in required capacity from 6,000 GPM to 21,700 GPM (+197,000)

f. Engineering and Design $+117,000

Increase due to direct proportion of estimated construction costs

g. Supervision and Administration $+113,000

Increase due to direct proportion of estimated construction costs

85. The difference in non-Federal first cost ($574,000 between this design memorandum cost estimate ($13,884,000) and the current approved estimate from PB-3 effective October 1983 ($3,310,000) is attributable to the following:

a. Lands and Damages $-110,000

Decrease due to redesign of both creek diversions

b. Relocations $+684,000

(1)	Increase due to addition of Highway 10 road raise	(+9,000)
(2)	Increase due to addition of Hickory Street access road	(+17,000)
(3)	Increase due to addition of removal and reconstruction of Hillside Drive bridge	(+138,000)
(4)	Increase due to addition of removal of Engler Boulevard culvert	(+12,000)
(5)	Increase due to addition of Engler Boulevard Bridge	(+264,000)
(6)	Decrease due to elimination of removal and reconstruction of Highway 212 Bridge	(-385,000)
(7)	Decrease due to elimination of construction of County 17 Bridge	(-150,000)
(8)	Increase due to addition of Brandon Boulevard Bridge	(+168,000)
(9)	Increase due to refinement of design and cost estimate of bridges at Highway 41 Hickory Street, and First Street	(+510,000)

(10) Increase due to utility changes resulting from the redesign of East Creek Diversion. (+101,000)

BENEFITS AND COST ALLOCATION

86. A full discussion of the benefits attributed to this project is contained in appendix E of this report. The results of the economic analysis are shown below.

87. National economic development benefits attributable to the proposed project include flood damage reduction, saving of flood insurance administrative costs, and recreation. Total equivalent annual benefits are $2,301,000, as summarized in the following table.

Table 3
Benefit Summary, Chaska, Minnesota
(October 1983 Prices; 8 7/8 percent Discount Rate)

Benefit	Without Levee Equivalent Annual Amount	With Levee Equivalent Annual Amount
Flood damage reduction	$2,264,000	$2,267,000
Saving of flood insurance administrative costs	9,000	9,000
Recreation	28,000	28,000
Total	$2,301,000	$2,304,000

88. Annual costs for the project are the sum of amortized first costs and annual operations and maintenance costs. First costs include no interest during construction because each separable feature of the project will be completed in one construction season. The following calculations show annual costs to be $2,076,000.

Table 4
Calculation of Annual Charges for the Proposed Project, Chaska Minnesota (October 1983 Prices: 8 1/8 percent Discount Rate)

Item	Amount
Federal and Non-Federal first cost	$23,596,000
Interest during construction	1,415,000
Total Investment cost	$25,011,000
Interest and amortization Construction Costs on an annual basis	2,033,000

Annual maintenance for flood control components	40,000
Annual maintenance for recreation components	3,000
Total annual charges	$ 2,076,000

89. The project has net annual benefits of $225,000, giving it a benefit-cost ratio of 1.11.

Table 5
Benefit-Cost Analysis, Chaska, Minnesota
(October 1983 Prices; 8 1/8 percent Discount Rate)

Item	Amount
Equivalent annual benefits	$2,301,000
Annual costs	2,076,000
Net Benefits	$ 225,000
Benefit-cost ratio	1.11

OPERATION AND MAINTENANCE

90. Local interests would maintain the project according to procedures and schedules set forth in a maintenance manual to be provided by the Corps of Engineers. Maintenance would consist of periodic inspection and repair as required on both channels, inlet and outlet structures, the conduit, and the two levee systems. Operations would include operation of the pumping station and all gate closures on the project, and the servicing and maintenance of equipment, structures, and related landscaping, as necessary. Maintenance schedules and instructions will be provided to the appropriate local officials for completed features of the partially completed project as soon as they become functional. This will ensure proper operation of the partially completed project during the extended period required for construction of the total project.

SCHEDULE FOR DESIGN AND CONSTRUCTION

91. The schedule for design and construction is shown in the tables below and is subject to the availability of funds. Three stages were used in scheduling construction. Stage I is the Chaska Creek diversion, stage II is the East Creek diversion, and stage III is the Minnesota River levees, pumping station, and associated interior drainage features.

R-August 84

Table 6
Schedule for Design and Construction

Stage	Submit FDM	Submit P&S	Advertise	Award	Construction Completion
I	Jul 84	Feb 85	May 86	Jun 86	Sep 88
II	Aug 85	Oct 86	Apr 87	May 87	Sep 89
III	Jul 86	Sep 87	Mar 88	Apr 88	Sep 89

Table 7
Proposed Funding Schedule

Fiscal Year	Amount
1984	$ 300,000
1985	291,000
1986	1,978,000
1987	7,619,000
1988	8,184,000
1989	4,113,000

LOCAL COOPERATION

92. The local project sponsor is the city of Chaska, Minnesota. By resolution dated 12 June 1973 and letters from the mayor dated 29 October 1976 and 7 May 1981, the city of Chaska has indicated its willingness and intent to meet the requirements of local cooperation. The items of local cooperation include:

a. Provide without cost to the United States all lands, easements, and rights-of-way, including borrow areas and disposal areas for excavated material determined suitable by the Chief of Engineers and necessary for construction of the project;

b. Hold and save the United States free from damages that may result from construction of the project, not including damages due to the fault or negligence of the United States or its contractors;

c. Maintain and operate all the works after completion in accordance with regulations prescribed by the Secretary of the Army (this is based on subsequent statute);

d. Accomplish without cost to the United States all relocations and alterations of buildings, transportation facilities, storm and sanitary sewer systems, public and private utilities, local betterments, drainage facilities, and other structures and improvements

made necessary by construction of the recommended plan, excluding railroad bridges and approachs and facilities necessary for the normal interception and disposal of local interior drainage at the line of protection;

e. Prescribe and enforce regulations to prevent obstruction or encroachment on channels and temporary storage areas which would reduce their flood-carrying or storage capacity or hinder maintenance and operation; if ponding areas are impaired, provide promptly and without cost to the United States substitute storage areas or equivalent pumping capacity;

f. Provide a cash contribution for recreation equal to 50 percent of the final separable cost allocated to this function, as outlined in the recreation cost-sharing contract.

g. Publicize floodplain information in the areas concerned and provide this information to zoning and other regulatory agencies for their guidance and leadership in preventing unwise future development in the floodplain. Provide guidance and leadership in adopting such regulations as may be necessary to ensure compatibility between future development and protection levels provided by the project; and

h. Inform affected interests at least annually of the limitations of the protection afforded by the project.

i. Comply with Section 601 of Title IV of the Civil Rights Act of 1964 (Public Law 88-352) and the Department of Defense Directive 5500.11 issued pursuant thereto and published in Part 300 of Title 32, Code of Federal Regulations, in connection with the maintenance and operation of the project.

j. Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, approved 2 January 1971, in acquiring lands, easements and rights-of-way, for construction and subsequent maintenance of the project and inform affected persons of pertinent benefits, policies, and procedures in connection with said Act.

93. General support for the project was expressed throughout the reevaluation public involvement program. Local interests have continued to express their concerns about flood control. Erosion near the existing city-owned levee along the Minnesota River has resulted in renewed requests for early action to solve the flood problems. The City Council and mayor of Chaska were advised of the current Administration's proposed up-front financing and cost-sharing policies, and they expressed their continued strong support of the project at a City Council meeting on 19 June 1982.

94. On 16 December 1982, the St. Paul District Engineer met with Mayor Tracy Swanson and members of her staff to reaffirm the city's understanding and support for the project and its interest in providing the required items of local cooperation under the cost-sharing policies now

being developed. The city of Chaska again indicated that it fully understands and supports the project, and by its letter of 21 February 1984 has indicated its intent to consider up-front project financing as agreed to in legislation by Congress and the current Administration. See appendix H for details of the above mentioned letters.

STATEMENT OF FINDINGS AND RECOMMENDATIONS

95. I have reviewed and evaluated the documents concerning the proposed action, the stated views of other interested agencies and the concerned public, and other pertinent information relative to providing flood protection to the city of Chaska, Minnesota.

BACKGROUND

96. The project was authorized by the 1976 Water Resource Development Act (Public Law 94-587) in response to local requests for relief from flooding such as that which occurred in 1965 and 1969. The authorized plan included upgrading and extending the existing Minnesota River levee system and the diversion of both Chaska and East Creeks. The St. Paul District published a limited reevaluation report and final supplement to the final environmental impact statement in August 1982 which recommended minor departures from the authorized plan but which retained the same concept for providing flood protection.

ALTERNATIVES

97. In addition to the no-action alternative, all other available means of reducing flood damages were investigated as alternatives to the proposed action in the 1973 feasibility report and the 1982 limited reevaluation report. Additionally, two value engineering studies were conducted during the preparation of this report. The recommendations of those studies were found to be in the public interest and have been incorporated into the recommended plan.

THE SELECTED PLAN

98. The recommended plan for providing flood protection to the city of Chaska includes the following structural measures. The existing Minnesota River levee system would be upgraded and extended around the east end of Courthouse Lake. A pumping station would be constructed at the south end of Pine Street to take care of seepage accumulation. Chaska Creek will be diverted around the outside of the upgraded levee using a rectangular, concrete supercritical flow channel. East Creek would be diverted through a reinforced concrete box culvert underneath Crosstown Boulevard. The northeastern quadrant of Chaska would be protected from flooding on East Creek by a low levee system which extends from Engler Boulevard along the natural drainage course to Crosstown Boulevard.

99. Other structural features in the plan include a drop structure upstream of Brandon Boulevard, a 48-inch reinforced concrete pipe underneath Crosstown Boulevard to pass normal East Creek flows, and the inlet and outlet structures associated with the two diversions.

ENVIRONMENTAL CONSIDERATIONS

100. The recommended plan has been designed to minimize any adverse impacts on the environment. The most significant impact is the replacement of the natural streambed of Chaska Creek with a reinforced concrete channel. Other significant impacts include restriction of public access to the wildlife refuge, the loss of about 20 acres of floodplain forest to the project features, and the residential relocations.

101. To help offset the environmental losses attributable to the project, the plan would include several mitigation features. These features include structural habitat improvement measures in the refuge, a planting plan on project lands, landscaping, and beautification measures in conjunction with the recreation plan. There will be no fee title acquisition of lands for mitigation.

SOCIAL CONSIDERATIONS

102. The selected plan would provide the flood protection considered necessary for the city of Chaska. Direct benefits would accrue from the protection of residences and businesses located in the floodplain. The plan would reduce the threat to life and the anxieties commonly associated with flooding.

ECONOMIC CONSIDERATIONS

103. Annual benefits and costs are $2,301,000 and $2,076,000, respectively for the overall project. The benefit-cost ratio is 1.11.

CONCLUSION

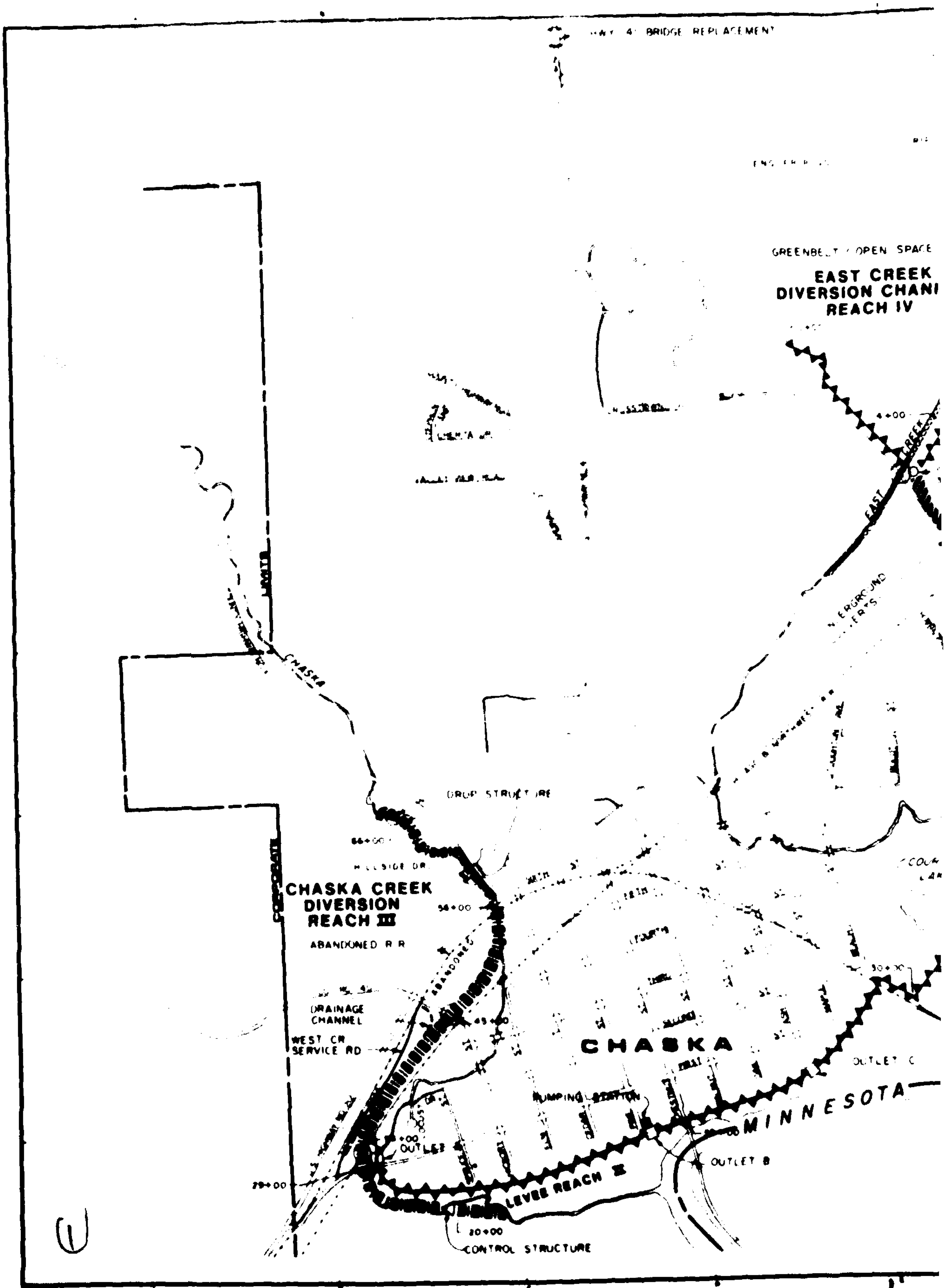
104. I find that the development of the selected plan in this general design memorandum is based on thorough analysis and investigation of various practicable alternative designs for achieving the objectives established by Congress.

RECOMMENDATION

106. Recommend approval of the plan of improvement for flood control presented herein, consisting of upgrading and extending the Minnesota River levee system; construction of a pumping station; diverting Chaska Creek from its natural channel into a concrete channel outside the levee system; diverting flood flows from East Creek; constructing a low levee system along the west and south sides of Lion's Park to control East Creek flood flows above the diversion; construction of associated inlet, outlet, and control structures for both diversions; building about 1 1/2 miles of paved recreation trails, and environmental mitigation measures.

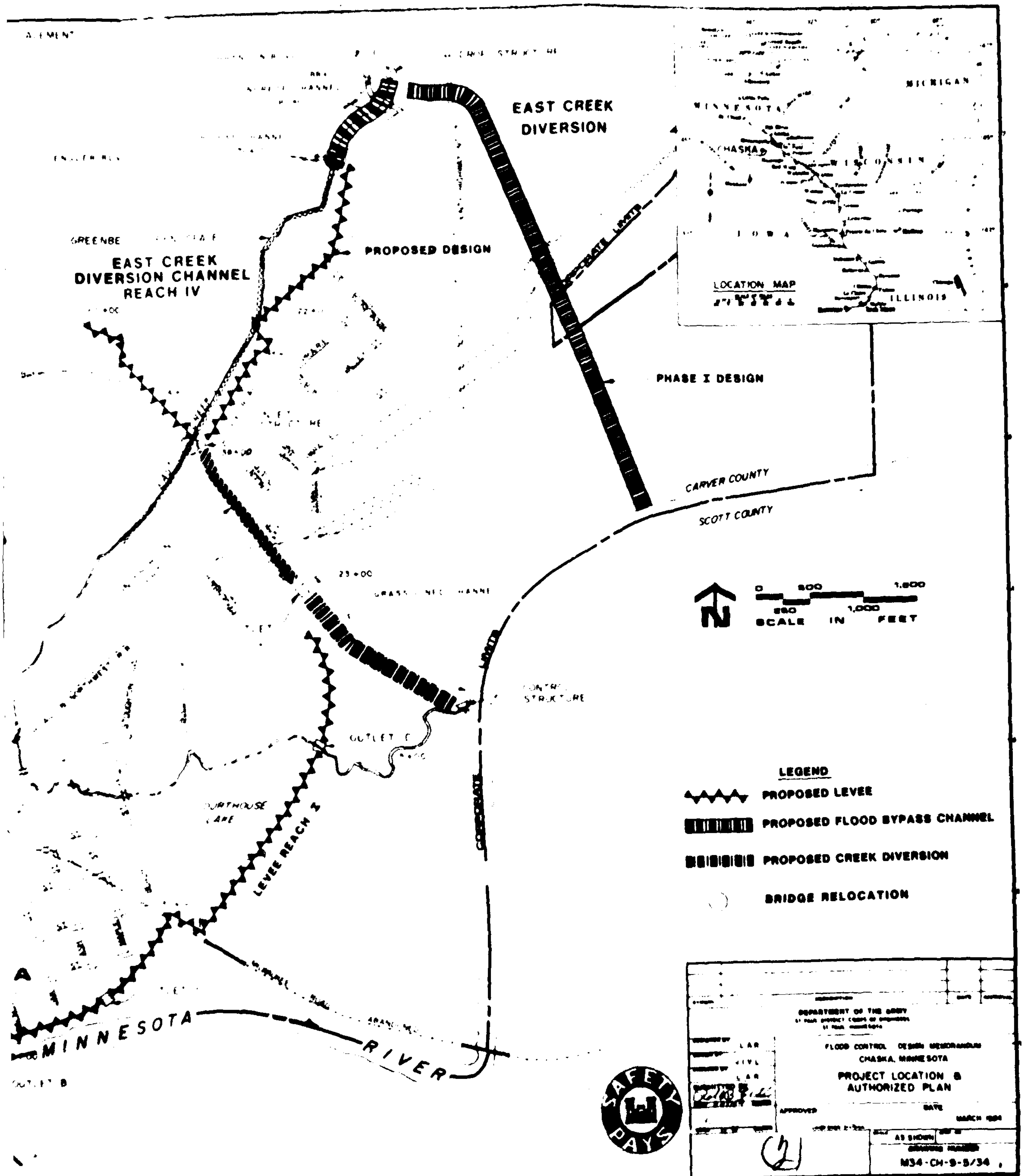
Edward G. Rapp

EDWARD G. RAPP
Colonel, Corps of Engineers
Commanding



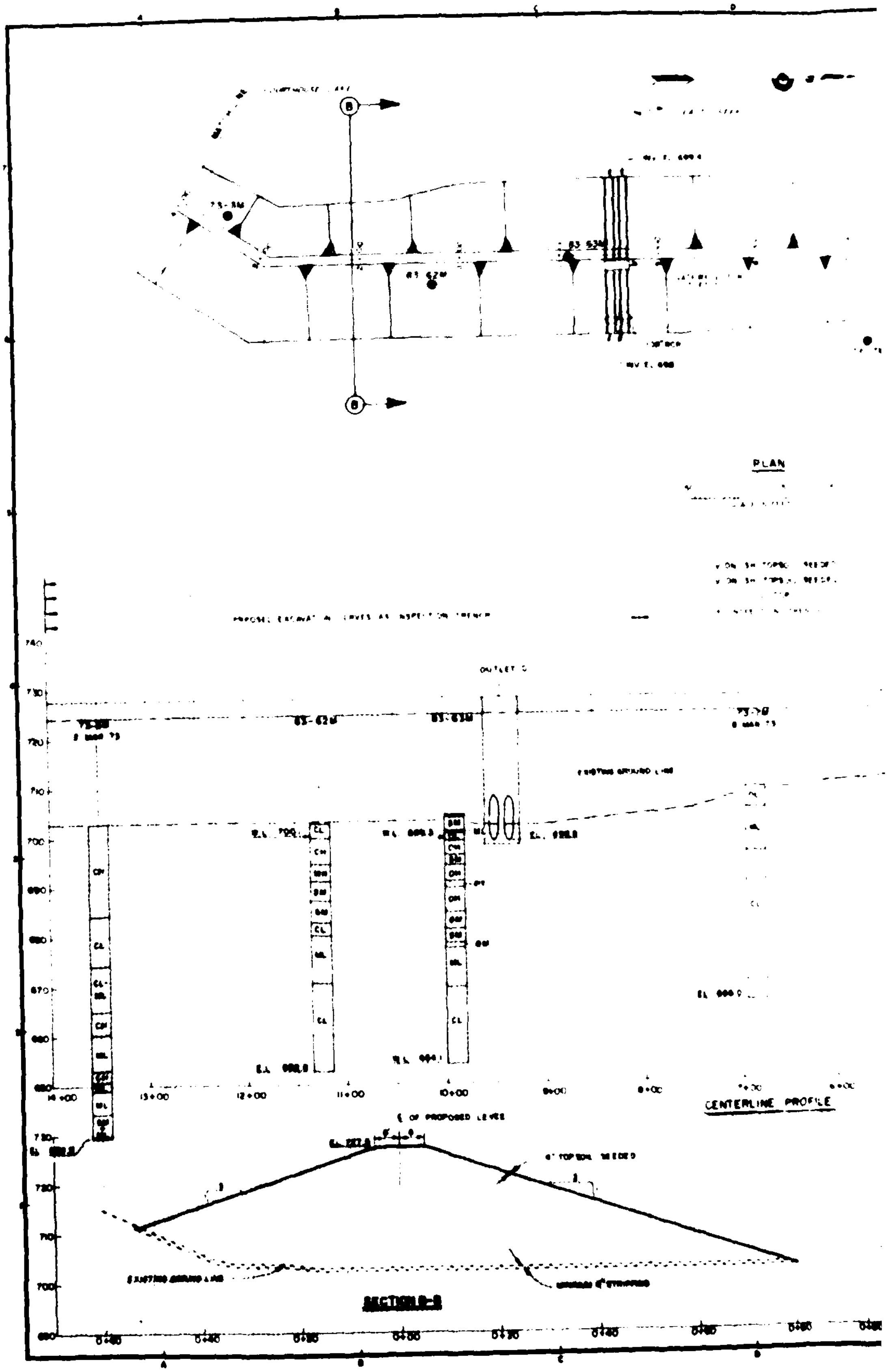
HWY 41 BRIDGE REPLACEMENT
GREENBELT / OPEN SPACE
EAST CREEK
DIVERSION CHAN
REACH IV
4+00
EAST CREEK
DROP STRUCTURE
66+00
HILLSIDE DR
CHASKA CREEK
DIVERSION
REACH III
56+00
ABANDONED R R
DRAINAGE
CHANNEL
WEST CR
SERVICE RD
CHASKA
OUTLET C
PUMPING STATION
OUTLET
MINNESOTA
OUTLET B
LEVEE REACH II
29+00
20+00
CONTROL STRUCTURE
30+00
CHASKA

(1)



EAST CREEK DIVERSION
PROPOSED DESIGN
EAST CREEK DIVERSION CHANNEL REACH IV
PHASE I DESIGN
CARVER COUNTY
SCOTT COUNTY
CONTROL STRUCTURE
LOCATION MAP
MICHIGAN
MINNESOTA
CHASKA
WISCONSIN
IOWA
ILLINOIS
0 500 1,500
250 1,000
SCALE IN FEET
LEGEND
PROPOSED LEVEE
PROPOSED FLOOD BYPASS CHANNEL
PROPOSED CREEK DIVERSION
BRIDGE RELOCATION
MINNESOTA RIVER
SAFETY PAYS
DEPARTMENT OF THE ARMY
FLOOD CONTROL DESIGN MEMORANDUM
CHASKA, MINNESOTA
PROJECT LOCATION & AUTHORIZED PLAN
MARCH 1984
AS SHOWN

PLATE 1



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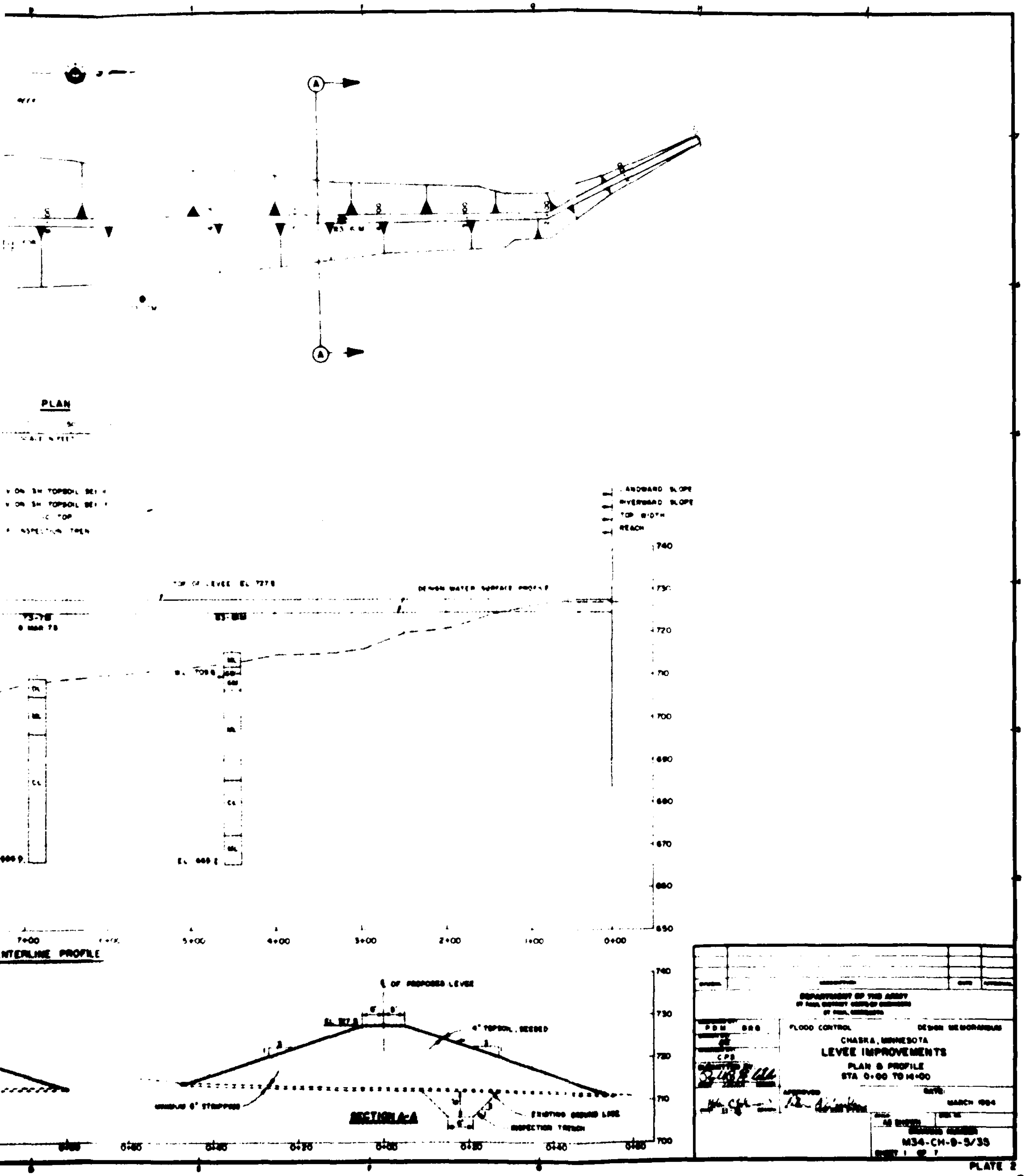
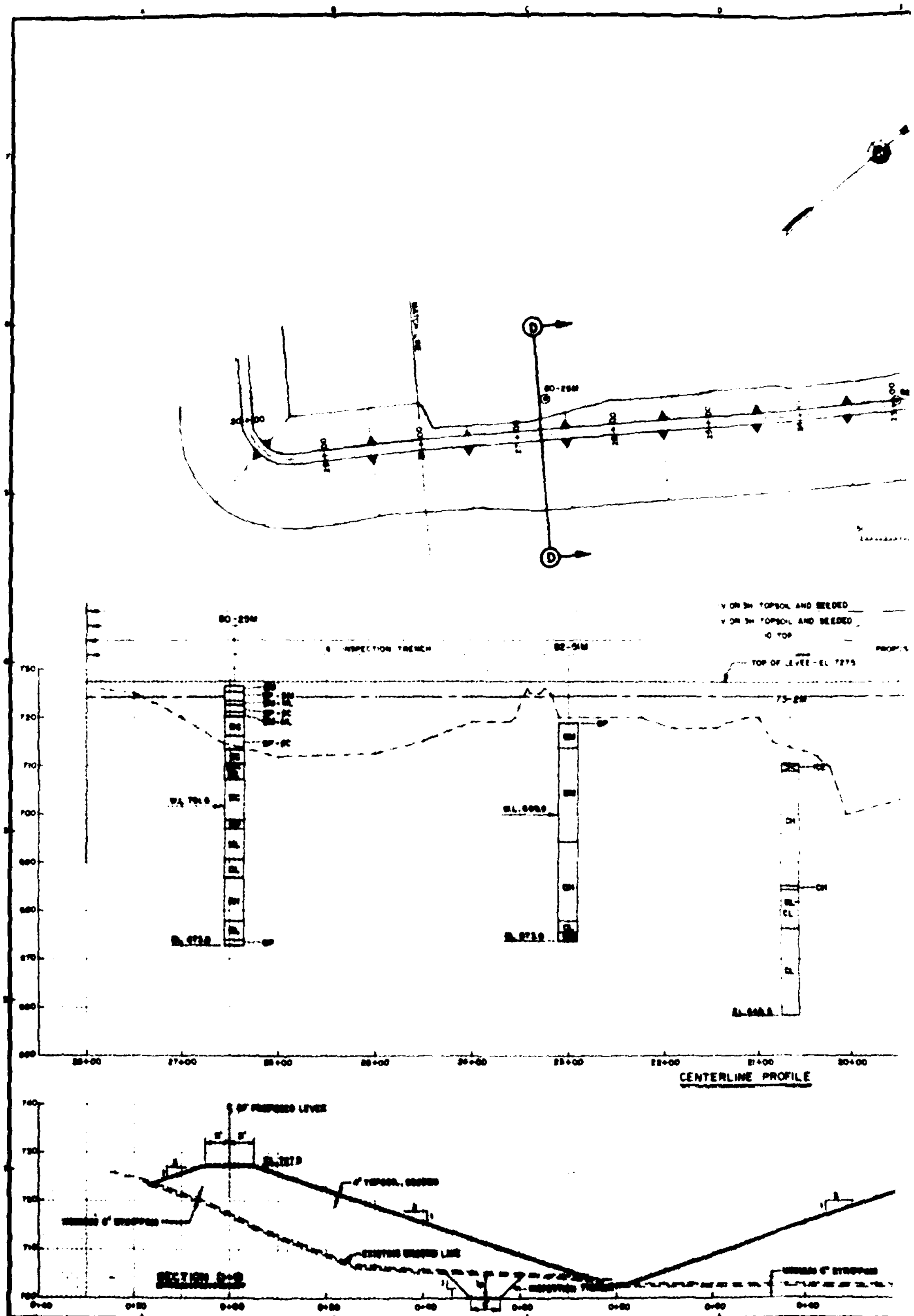

PLAN
LANDWARD SLOPE
RIVERWARD SLOPE
TOP WIDTH
REACH
TOP OF LEVEE EL 727.8
DESIGN WATER SURFACE PROFILE
740
730
720
710
700
690
680
670
660
650
7+00
5+00
4+00
3+00
2+00
1+00
0+00
NTERLINE PROFILE
℄ OF PROPOSED LEVEE
EL 727.8
4" TOPSOIL, SEEDED
EXISTING GROUND LINE
INSPECTION TRENCH
SECTION A-A
FLOOD CONTROL
DESIGN MEMORANDUM
CHASKA, MINNESOTA
LEVEE IMPROVEMENTS
PLAN & PROFILE
STA 0+00 TO 14+00
MARCH 1984
M34-CH-9-5/35

PLATE 2

(2)


BO-29M
INSPECTION TRENCH
CENTERLINE PROFILE
SECTION D-D
EXISTING GROUND LINE

(1)

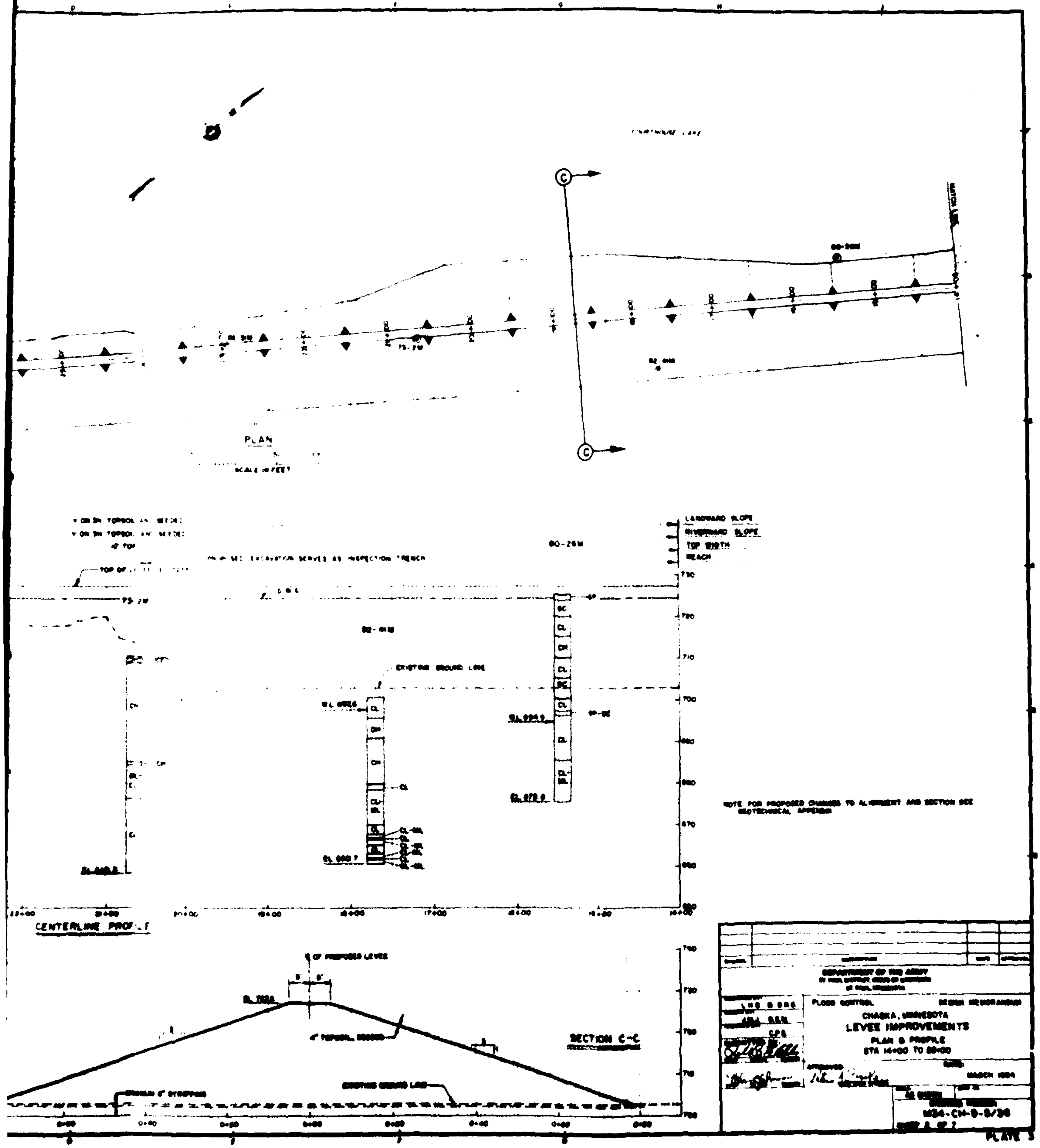
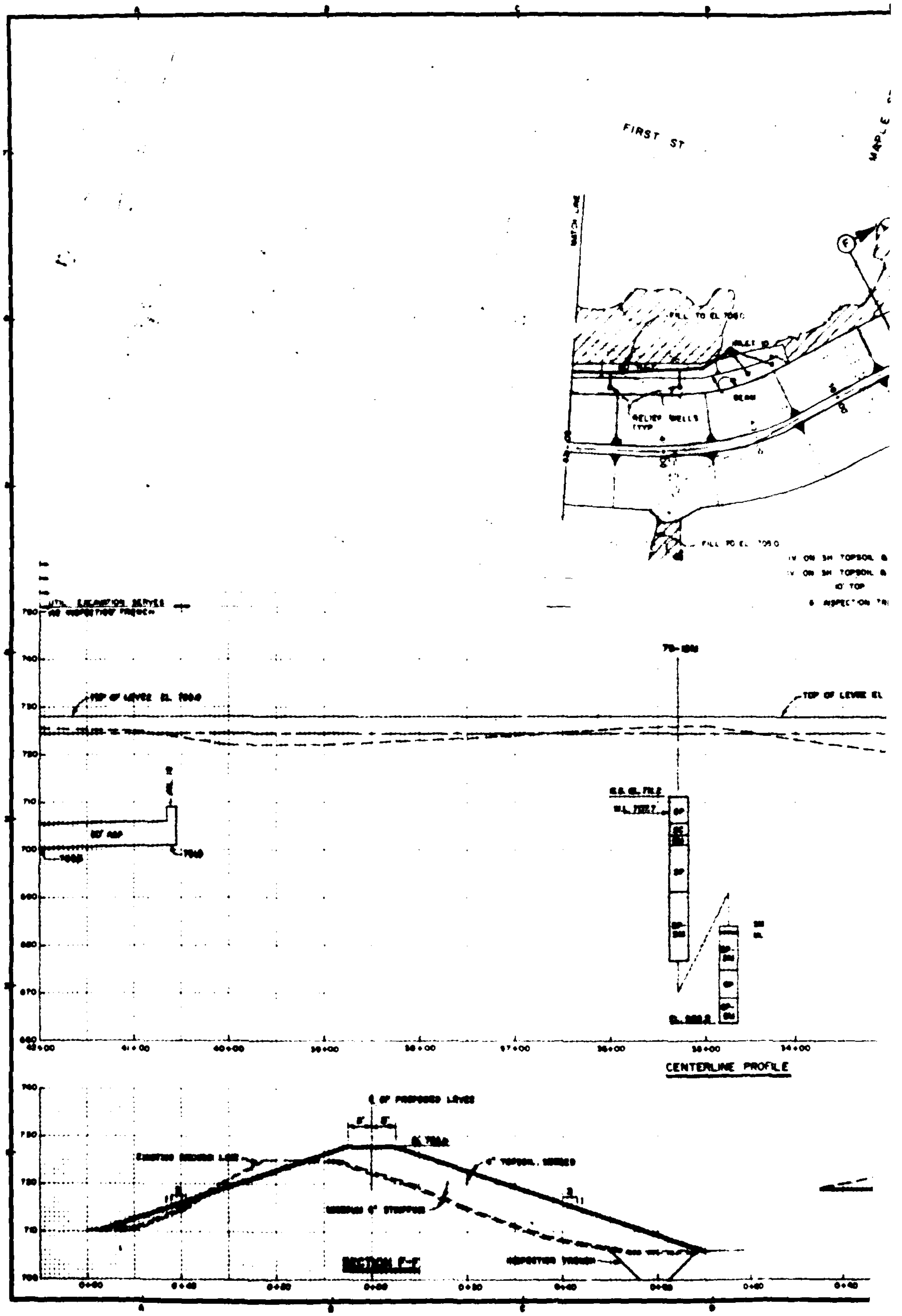
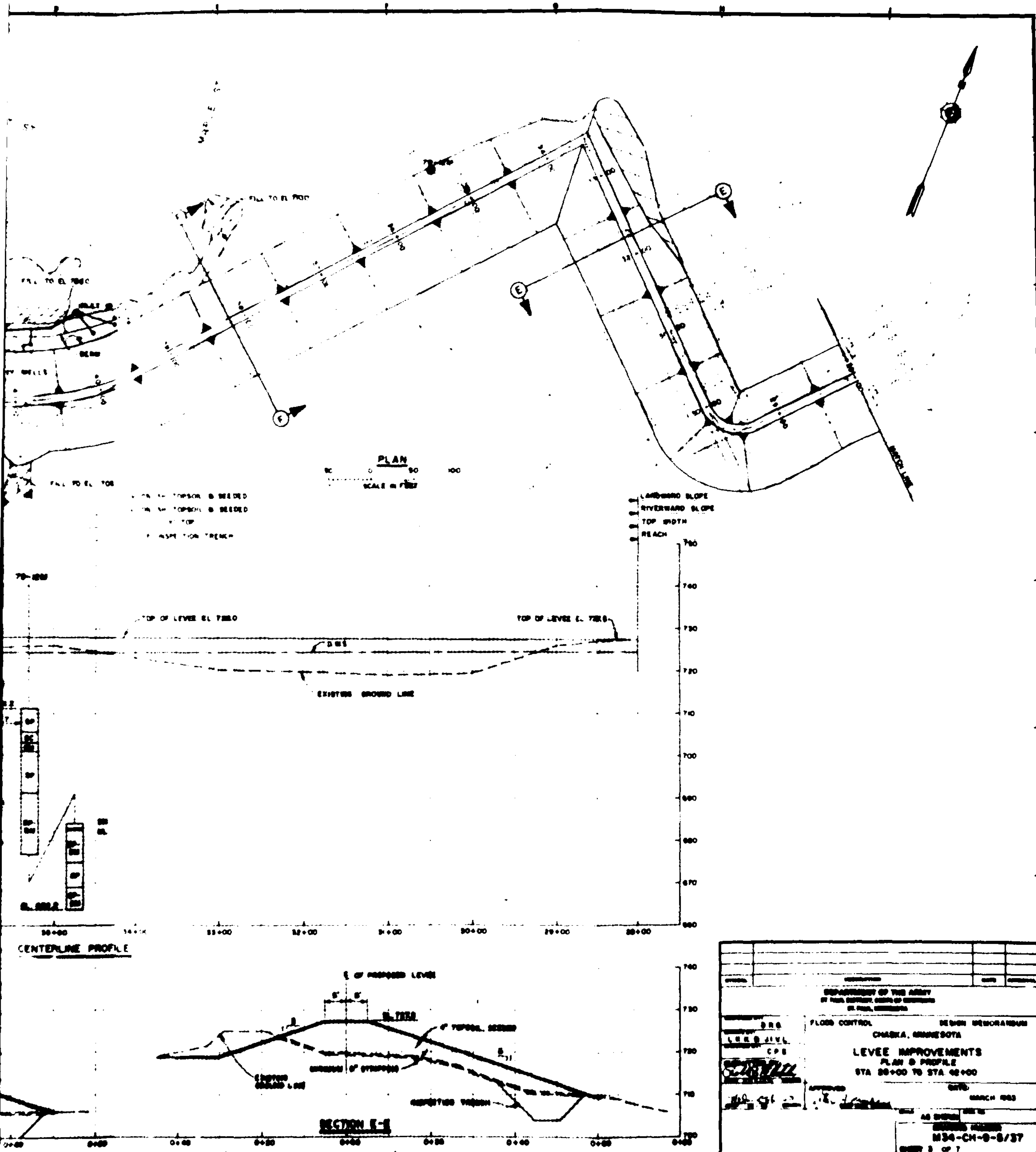

PLAN
SCALE IN FEET
LANDWARD SLOPE
RIVERWARD SLOPE
TOP WIDTH
REACH
EXISTING GROUND LINE
CENTERLINE PROFILE
NOTE: FOR PROPOSED CHANGES TO ALIGNMENT AND SECTION SEE GEOTECHNICAL APPENDIX
SECTION C-C
EXISTING GROUND LINE
FLOOD CONTROL
DESIGN MEMORANDUM
CHASKA, MINNESOTA
LEVEE IMPROVEMENTS
PLAN & PROFILE
STA 14+00 TO 23+00
MARCH 1984
M34-CH-9-5/36

PLATE 3

2



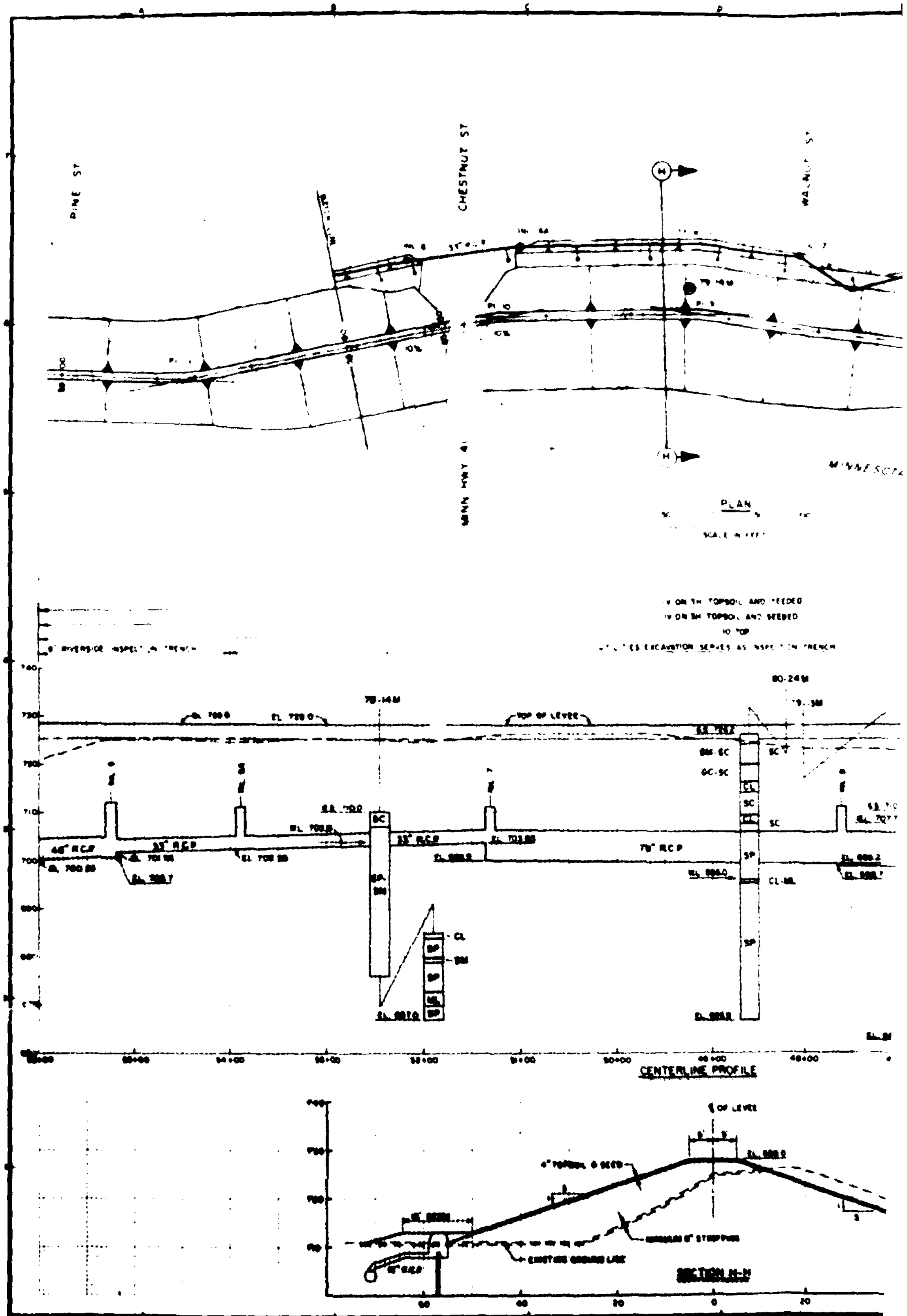
FIRST ST
RELIEF WELLS TYP
BERM
TOP OF LEVEE EL
CENTERLINE PROFILE
SECTION F-F
INSPECTION TRENCH



PLAN
SCALE IN FEET
LANDWARD SLOPE
RIVERWARD SLOPE
TOP WIDTH
REACH
EXISTING GROUND LINE
CENTERLINE PROFILE
SECTION E-E
INSPECTION TRENCH
FLOOD CONTROL
DESIGN MEMORANDUM
CHASKA, MINNESOTA
LEVEE IMPROVEMENTS
PLAN & PROFILE
MARCH 1983
AS SHOWN
M34-CH-8-8/37

PLATE 4

(9)



PINE ST
CHESTNUT ST
WALNUT ST
MINN HWY 41
PLAN
SCALE IN FEET
CENTERLINE PROFILE
TOP OF LEVEE
78" RCP
79-14M
80-24M
SECTION M-M
OF LEVEE
EXISTING GROUND LINE

(1)

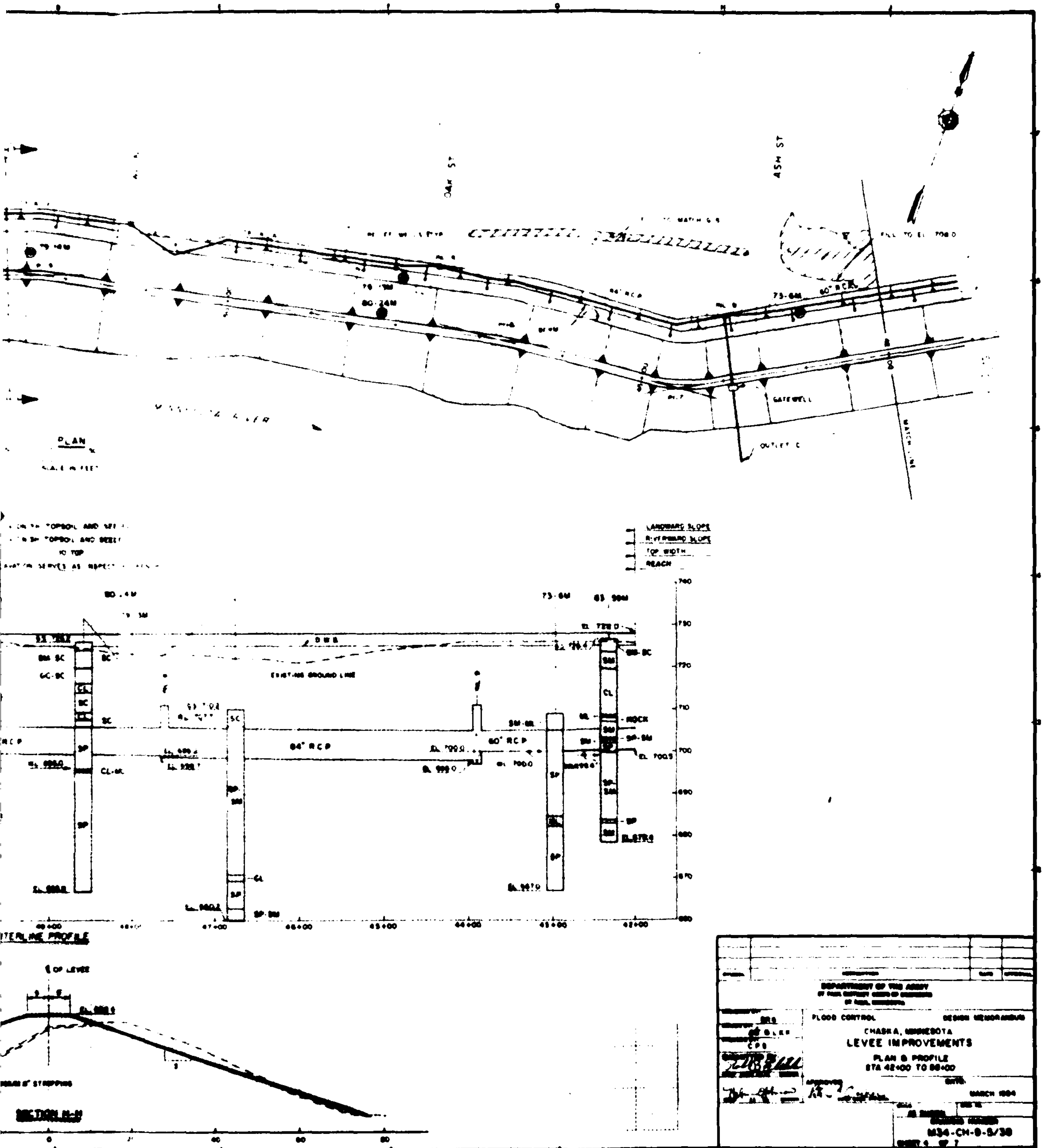
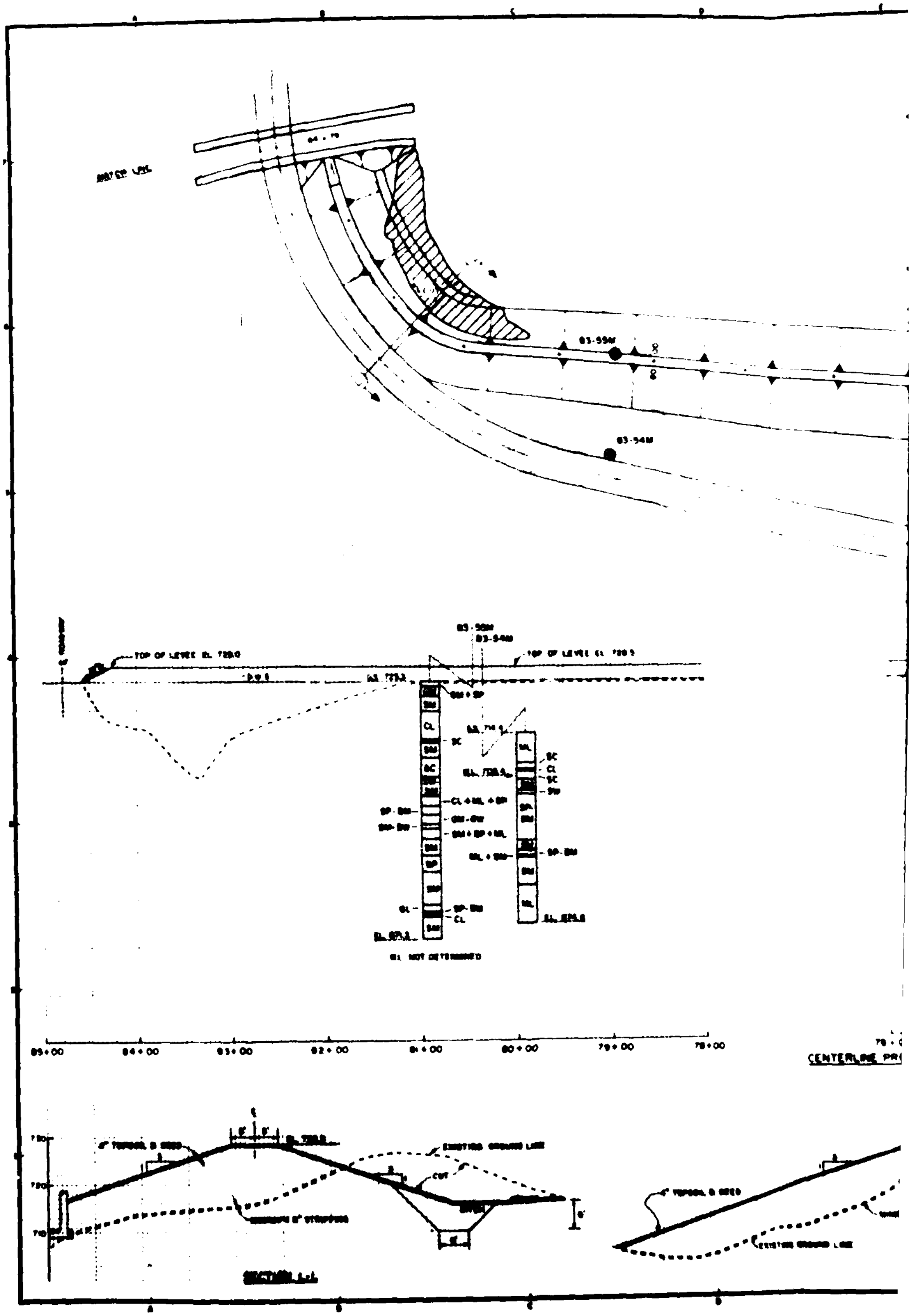

OAK ST
ASH ST
GATEWELL
PLAN
EXISTING GROUND LINE
84" RCP
60" RCP
LANDWARD SLOPE
RIVERWARD SLOPE
TOP WIDTH
REACH
ROCK
CENTERLINE PROFILE
℄ OF LEVEE
SECTION H-H
FLOOD CONTROL
DESIGN MEMORANDUM
CHASKA, MINNESOTA
LEVEE IMPROVEMENTS
PLAN & PROFILE
STA 42+00 TO 56+00
MARCH 1984
M34-CH-9-5/38

PLATE 5



83-55M
83-54M
85+00
84+00
83+00
82+00
81+00
80+00
79+00
78+00
CUT

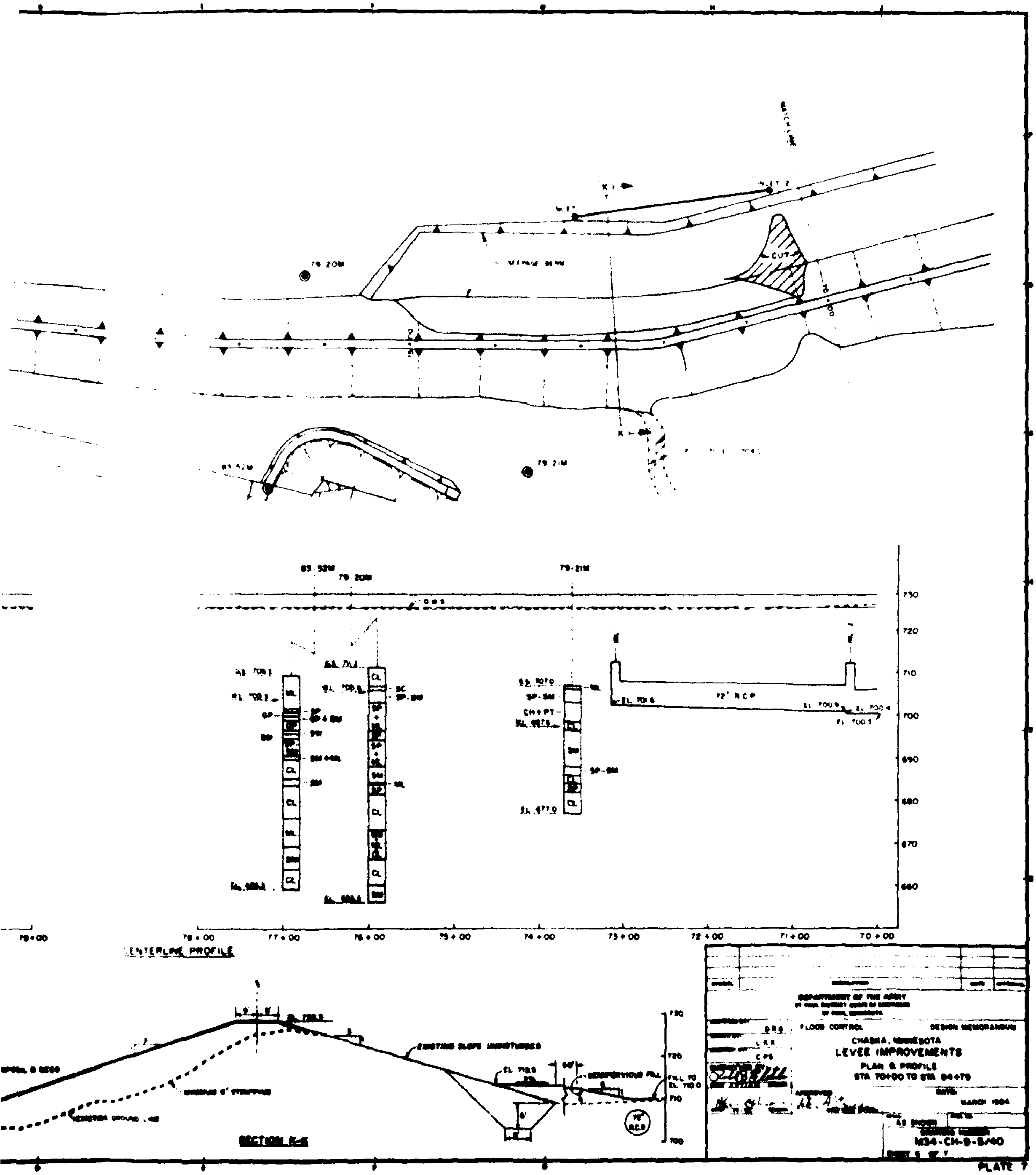
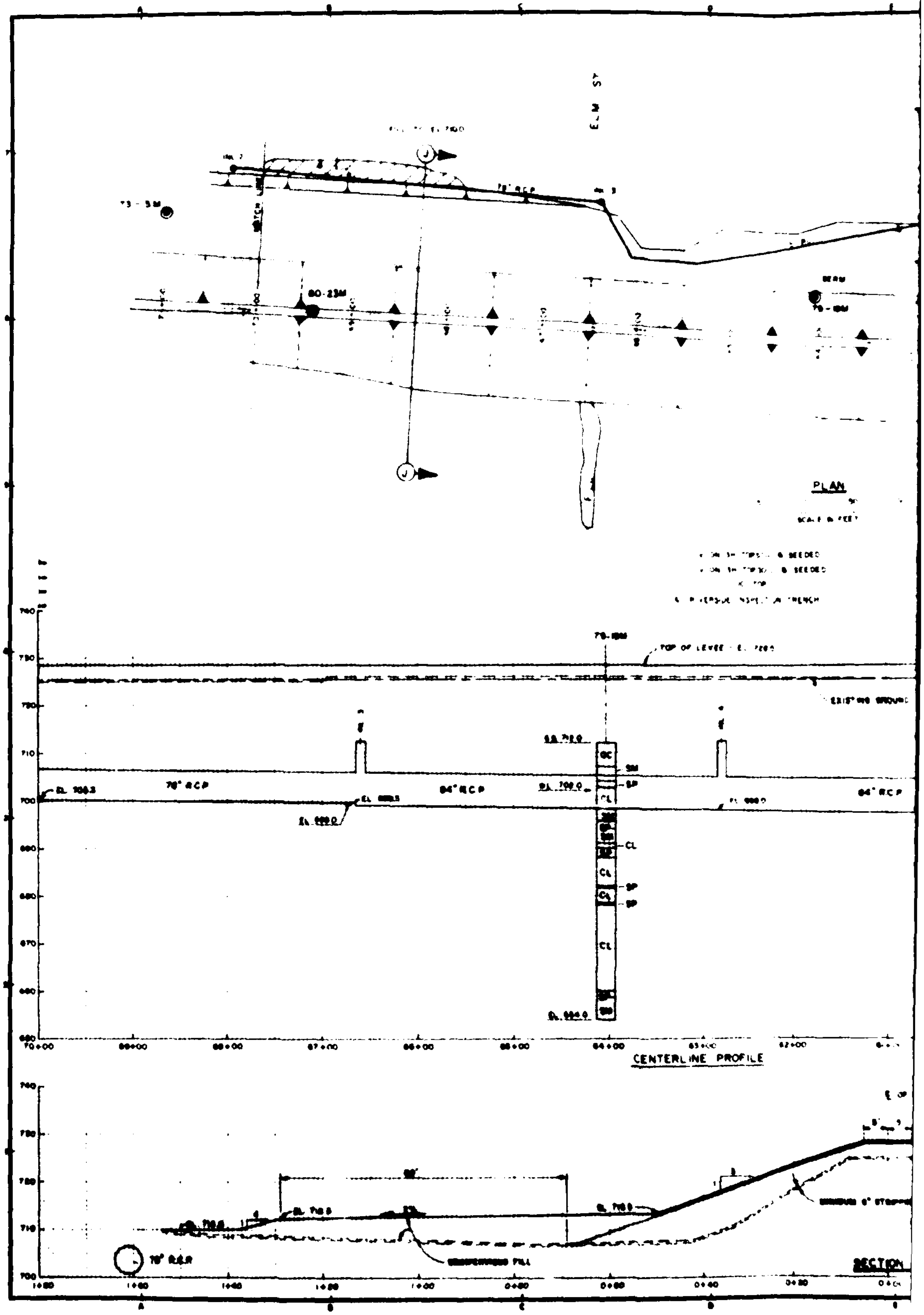

79-20M
79-21M
CUT
K
83-52M
O.H.S.
72" R.C.P.
EL 700.5
CENTERLINE PROFILE
77+00
76+00
75+00
74+00
73+00
72+00
71+00
70+00
730
720
710
700
690
680
670
660
EXISTING SLOPE UNDISTURBED
IMPERVIOUS FILL
FILL TO EL 710.0
EXISTING GROUND LINE
72" RCP
SECTION K-K
DEPARTMENT OF THE ARMY
FLOOD CONTROL
DESIGN MEMORANDUM
D.R.S.
L.K.R.
C.P.S.
LEVEE IMPROVEMENTS
PLAN & PROFILE
STA. 70+00 TO STA. 84+79
MARCH 1984
AS SHOWN
M34-CH-9-B/40

PLATE 7


ELM ST
PLAN
SCALE IN FEET
79-18M
80-23M
78" RCP
84" RCP
EL 700.0
EL 699.0
CENTERLINE PROFILE
SECTION
78" RCP

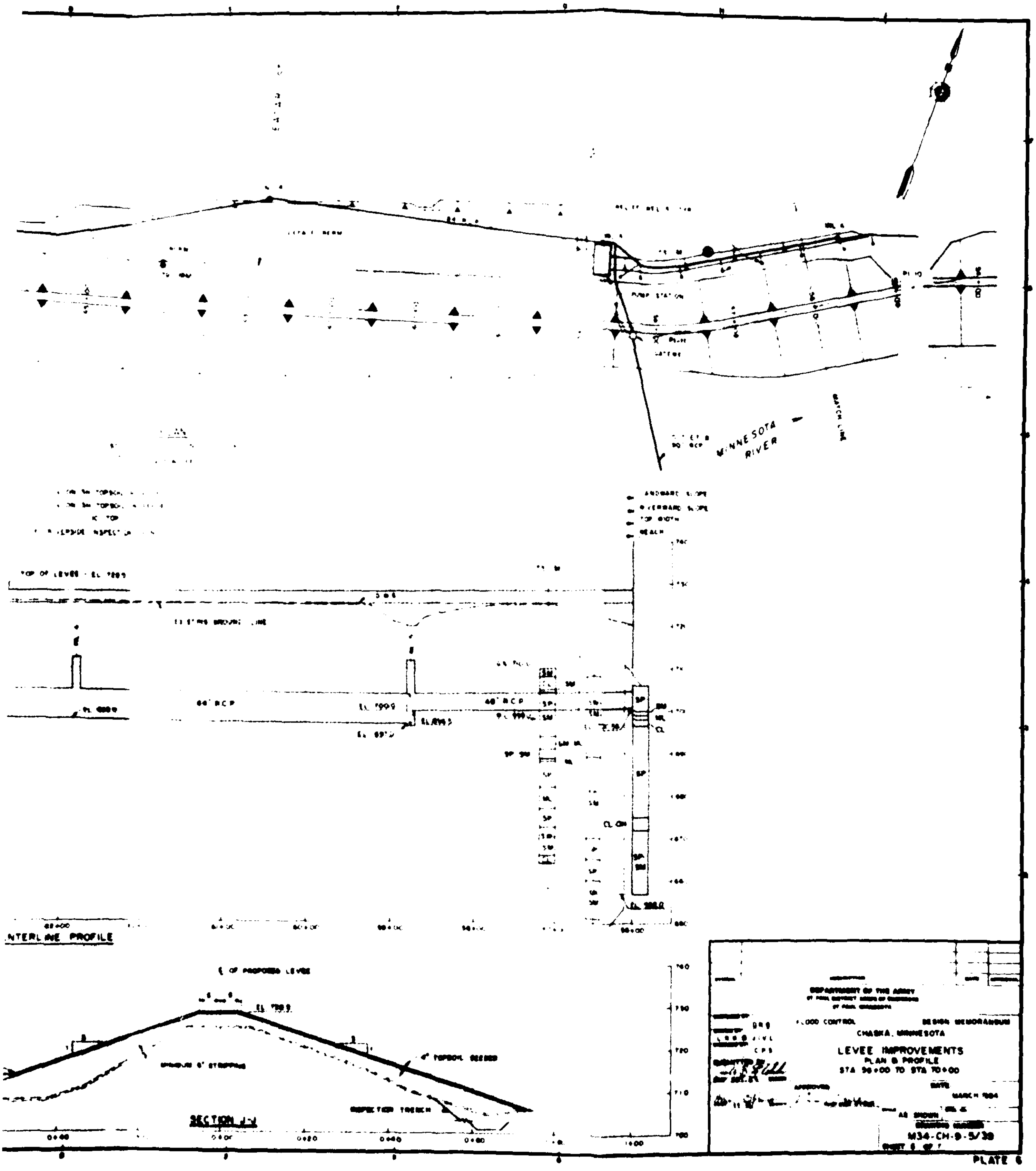
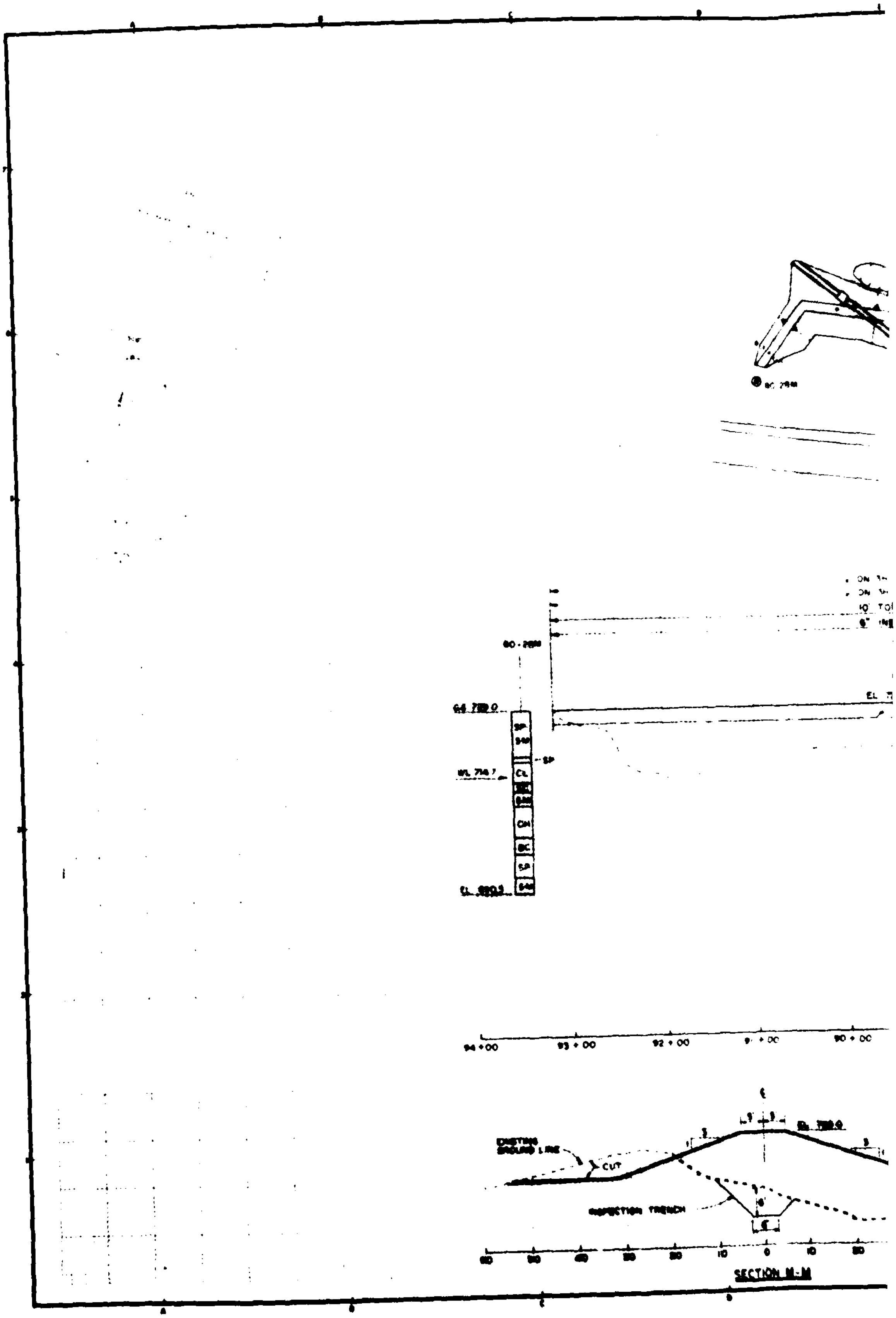
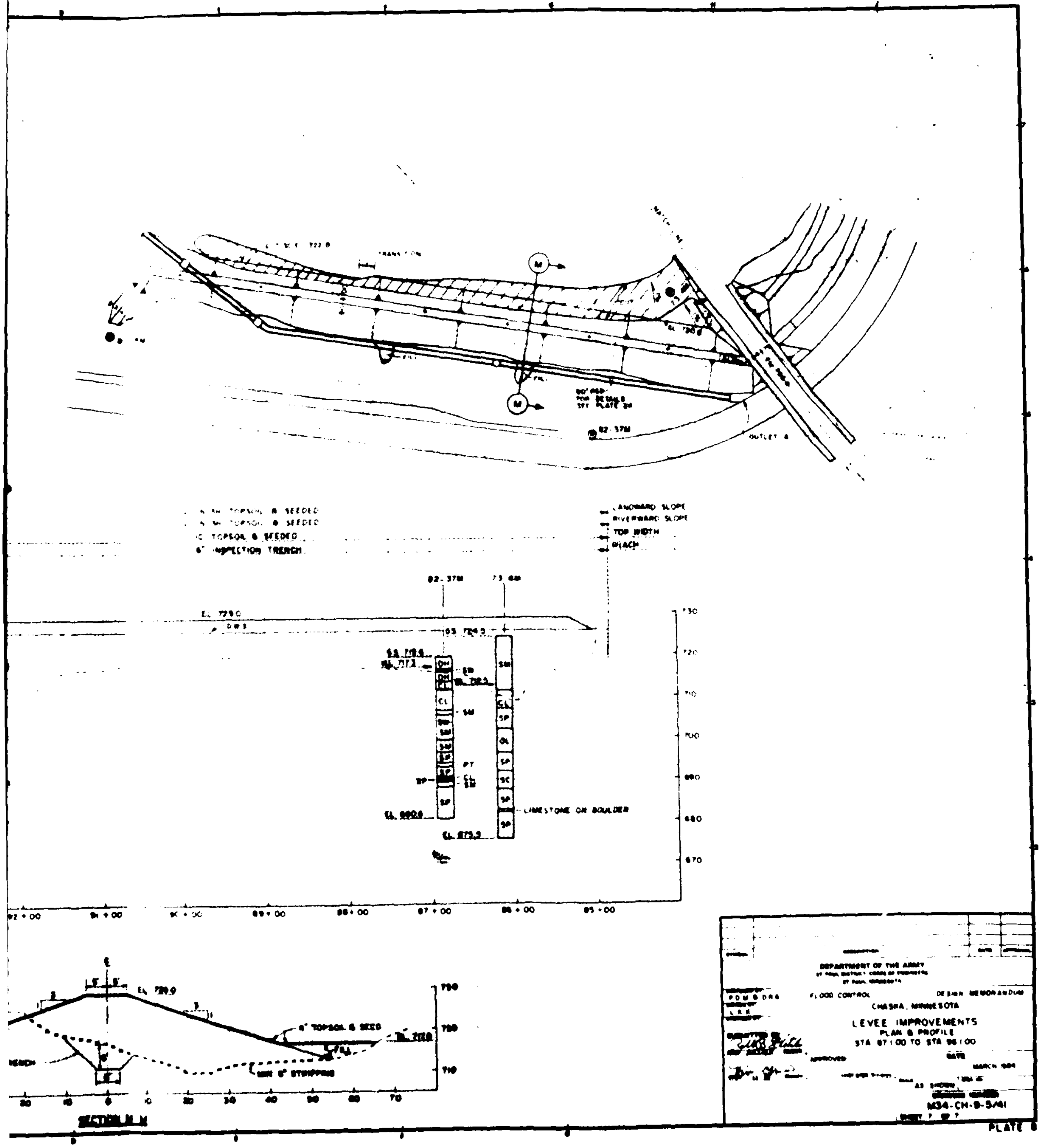
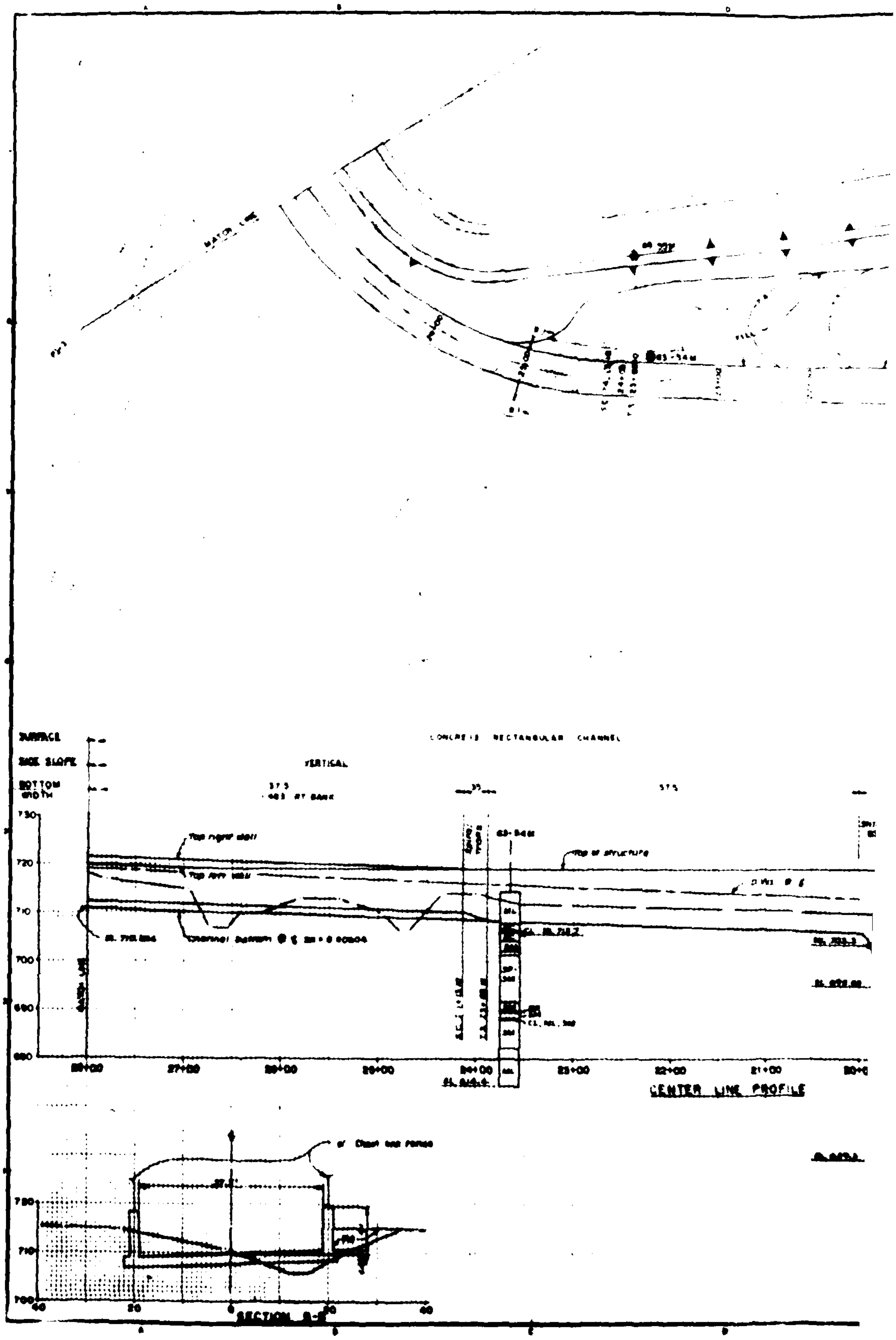

MINNESOTA RIVER
PUMP STATION
TOP OF LEVEE - EL 789.9
EXISTING GROUND LINE
48" RCP
EL 779.9
NTERLINE PROFILE
℄ OF PROPOSED LEVEE
EL 789.9
4" TOPSOIL SEEDED
INSPECTION TRENCH
SECTION J-J
DEPARTMENT OF THE ARMY
FLOOD CONTROL
DESIGN MEMORANDUM
CHASKA, MINNESOTA
LEVEE IMPROVEMENTS
PLAN & PROFILE
STA 56+00 TO STA 70+00
MARCH 1984
AS SHOWN
M34-CH-9-5/39

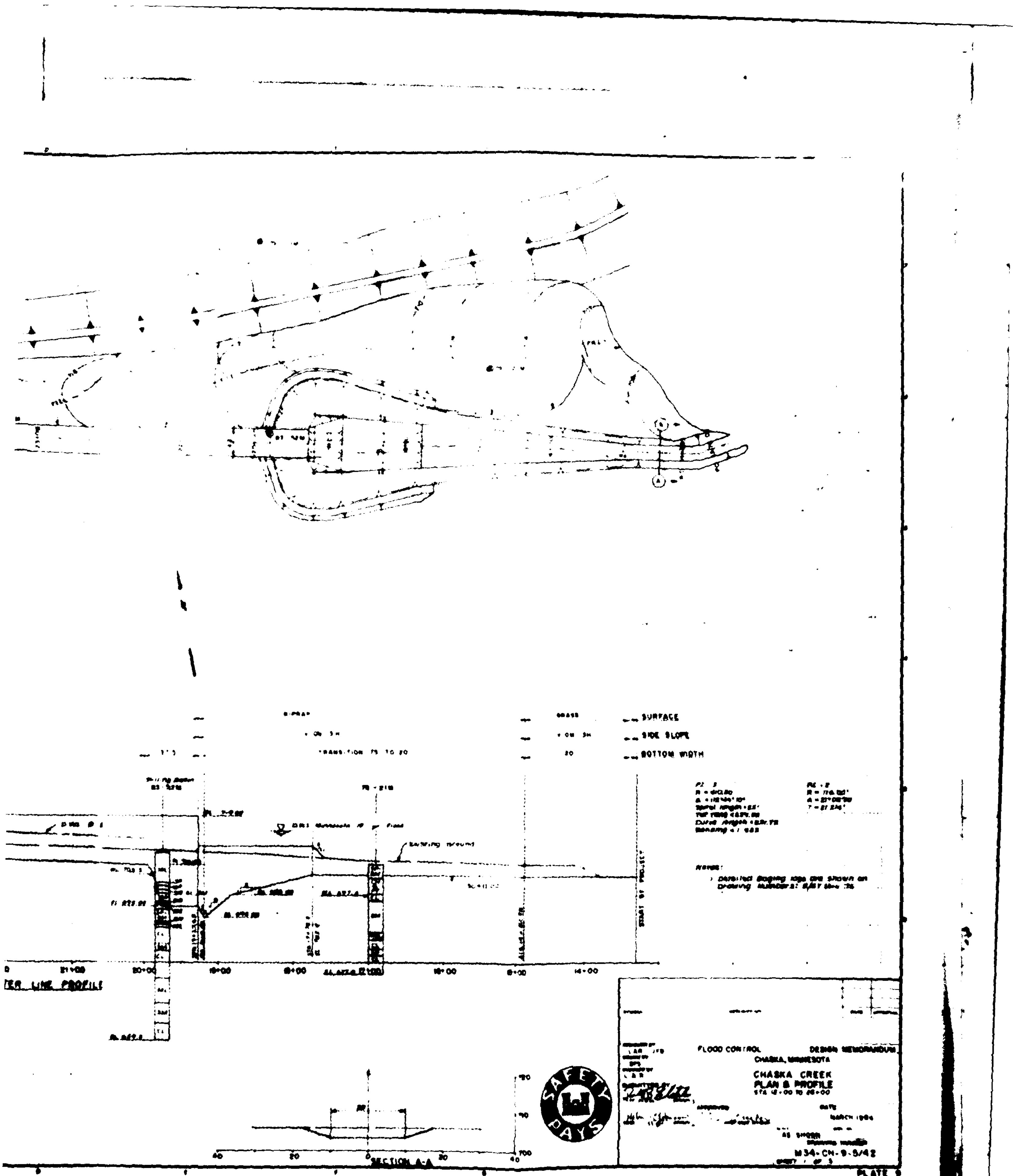
PLATE 6



94 + 00
93 + 00
92 + 00
90 + 00
EXISTING GROUND LINE
CUT
INSPECTION TRENCH
SECTION M-M

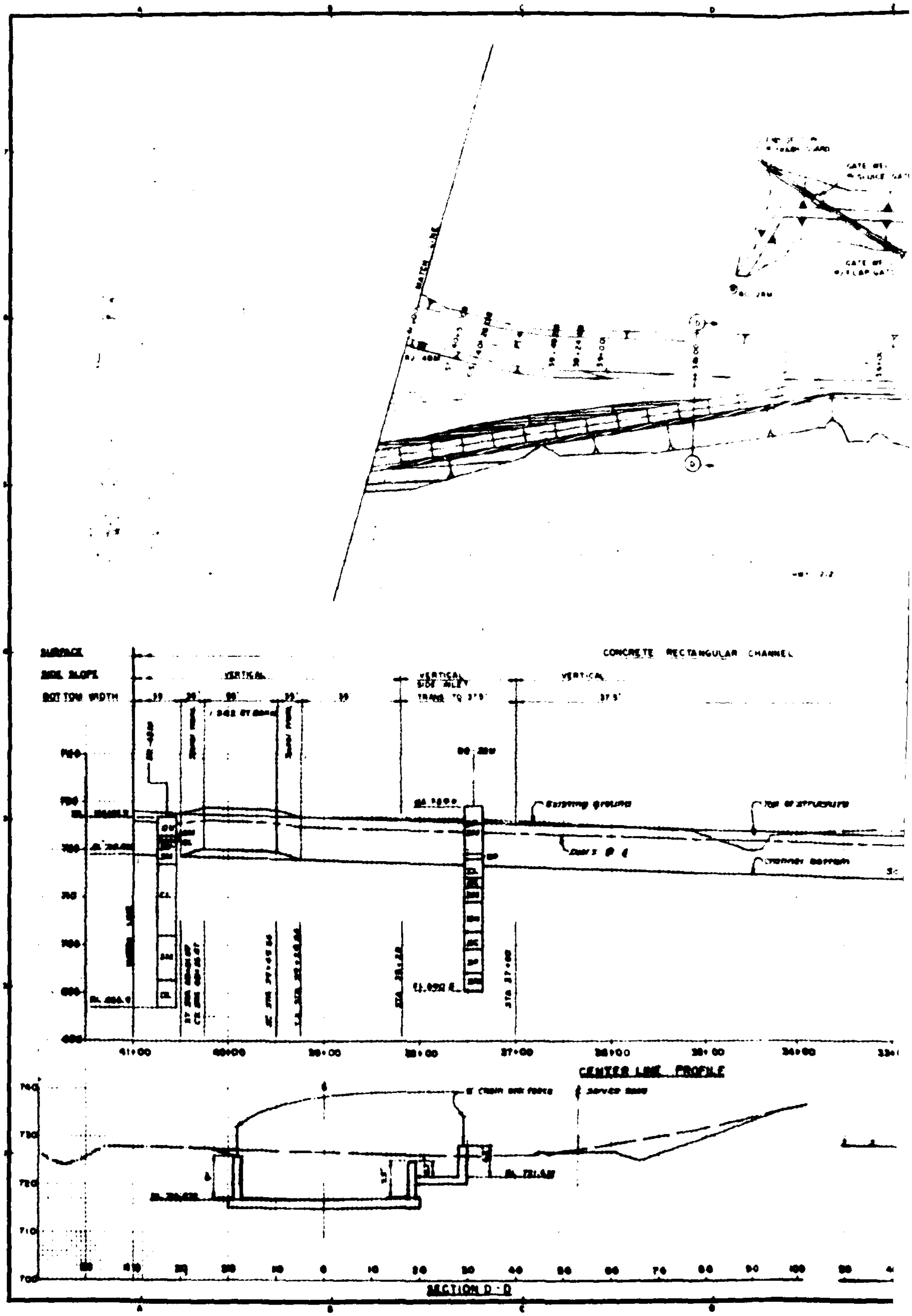

TRANSITION
LANDWARD SLOPE
RIVERWARD SLOPE
TOP WIDTH
TOPSOIL & SEEDED
6" INSPECTION TRENCH
82-37M
OUTLET 4
EL 729.0
LIMESTONE OR BOULDER
730
720
710
700
690
680
670
87+00
86+00
85+00
EL 729.0
6" TOPSOIL & SEED
MIN 6" STRIPPING
SECTION M-M
DEPARTMENT OF THE ARMY
FLOOD CONTROL
DESIGN MEMORANDUM
CHASKA, MINNESOTA
LEVEE IMPROVEMENTS
PLAN & PROFILE
STA 87+00 TO STA 96+00
PLATE 8


MATCH LINE
SURFACE
SIDE SLOPE
BOTTOM WIDTH
CONCRETE RECTANGULAR CHANNEL
VERTICAL
Top right wall
Top left wall
Top of structure
Channel bottom
730
720
710
700
690
680
28+00
27+00
26+00
25+00
24+00
23+00
22+00
21+00
CENTER LINE PROFILE
SECTION

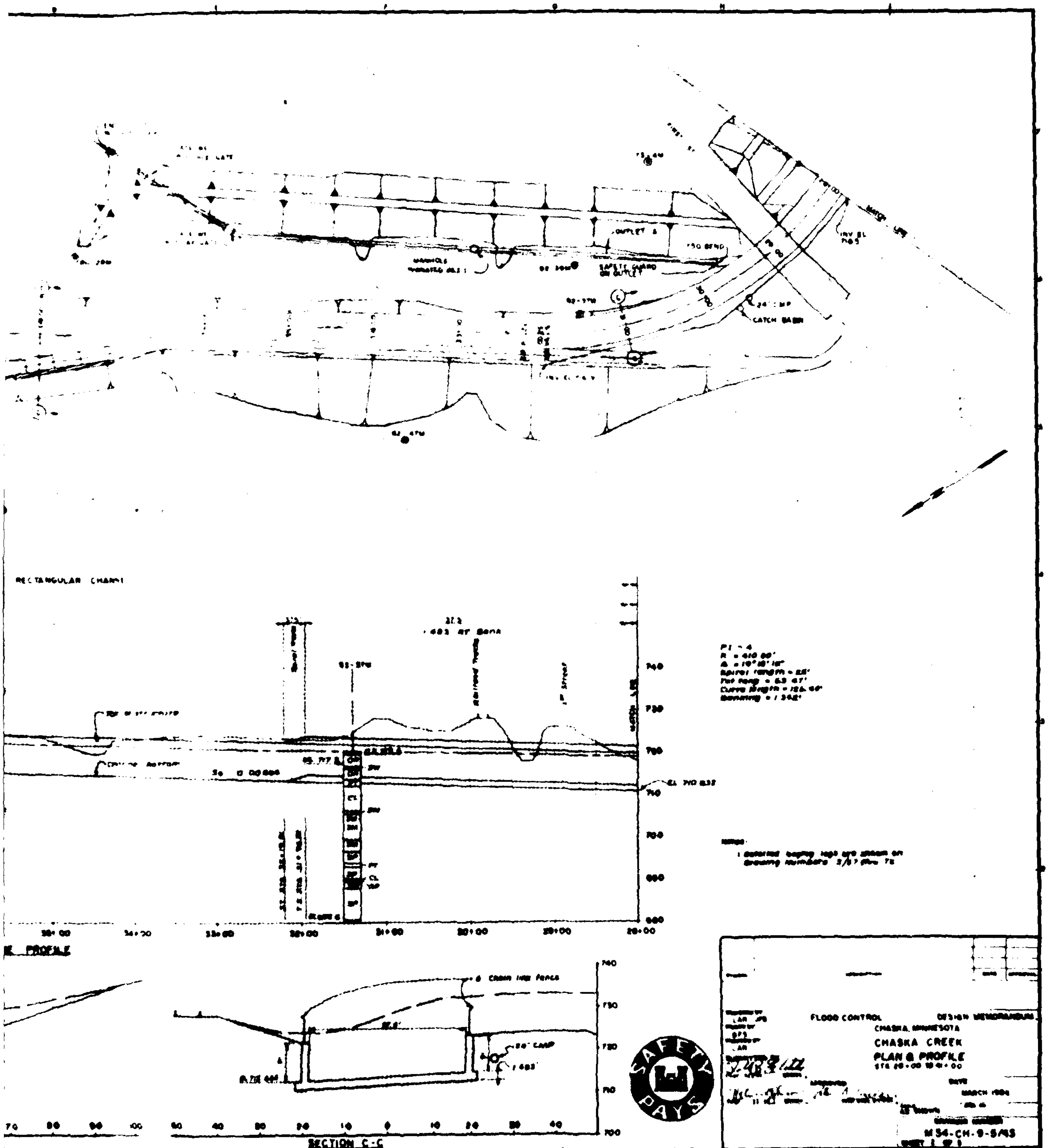


SURFACE
SIDE SLOPE
BOTTOM WIDTH
Existing Ground
20+00
19+00
18+00
17+00
16+00
15+00
14+00
START OF PROJECT
SECTION A-A
FLOOD CONTROL
DESIGN MEMORANDUM
CHASKA, MINNESOTA
CHASKA CREEK
PLAN & PROFILE
AS SHOWN
M34-CH-9-5/42
SAFETY PAYS

PLATE 9

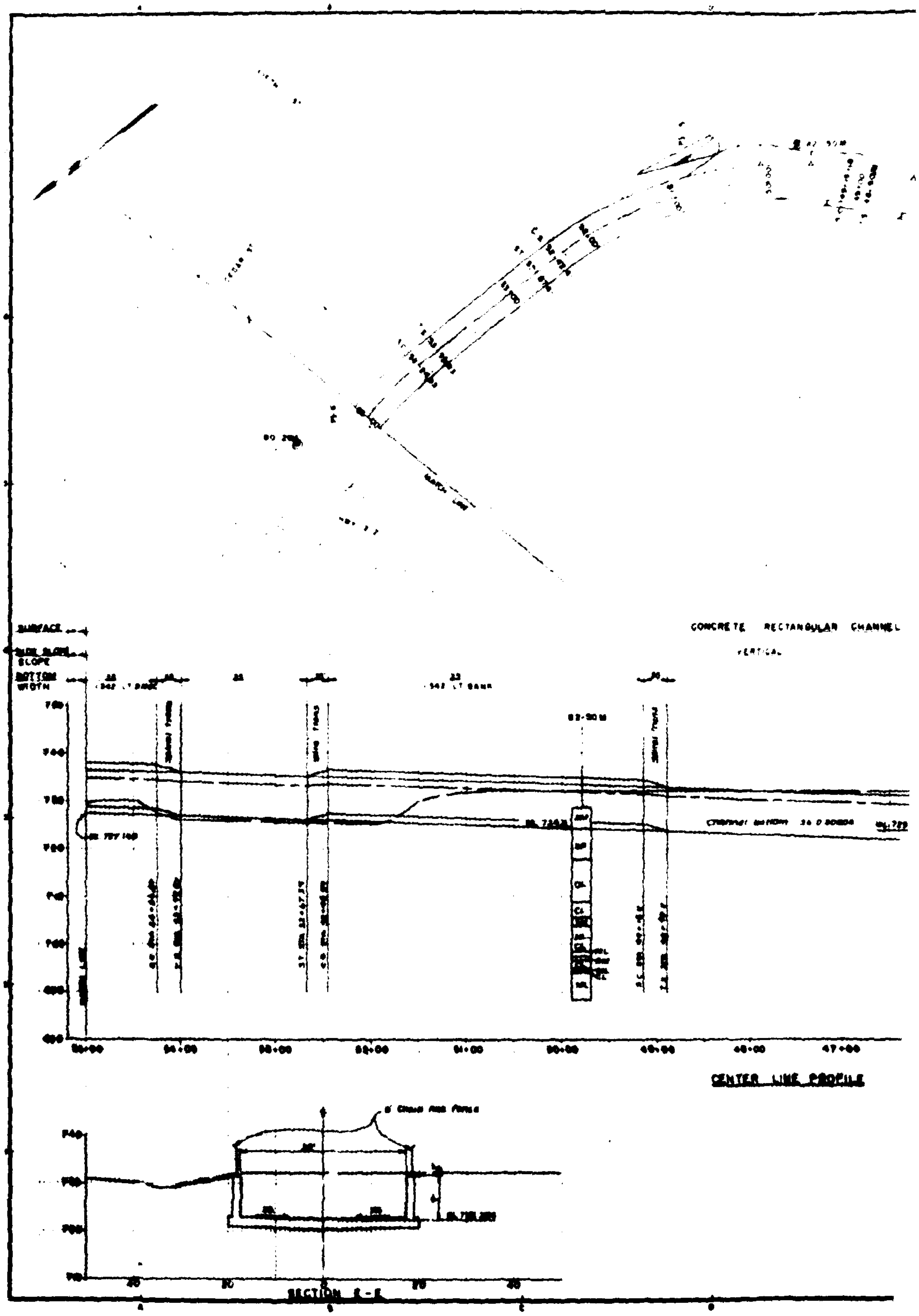


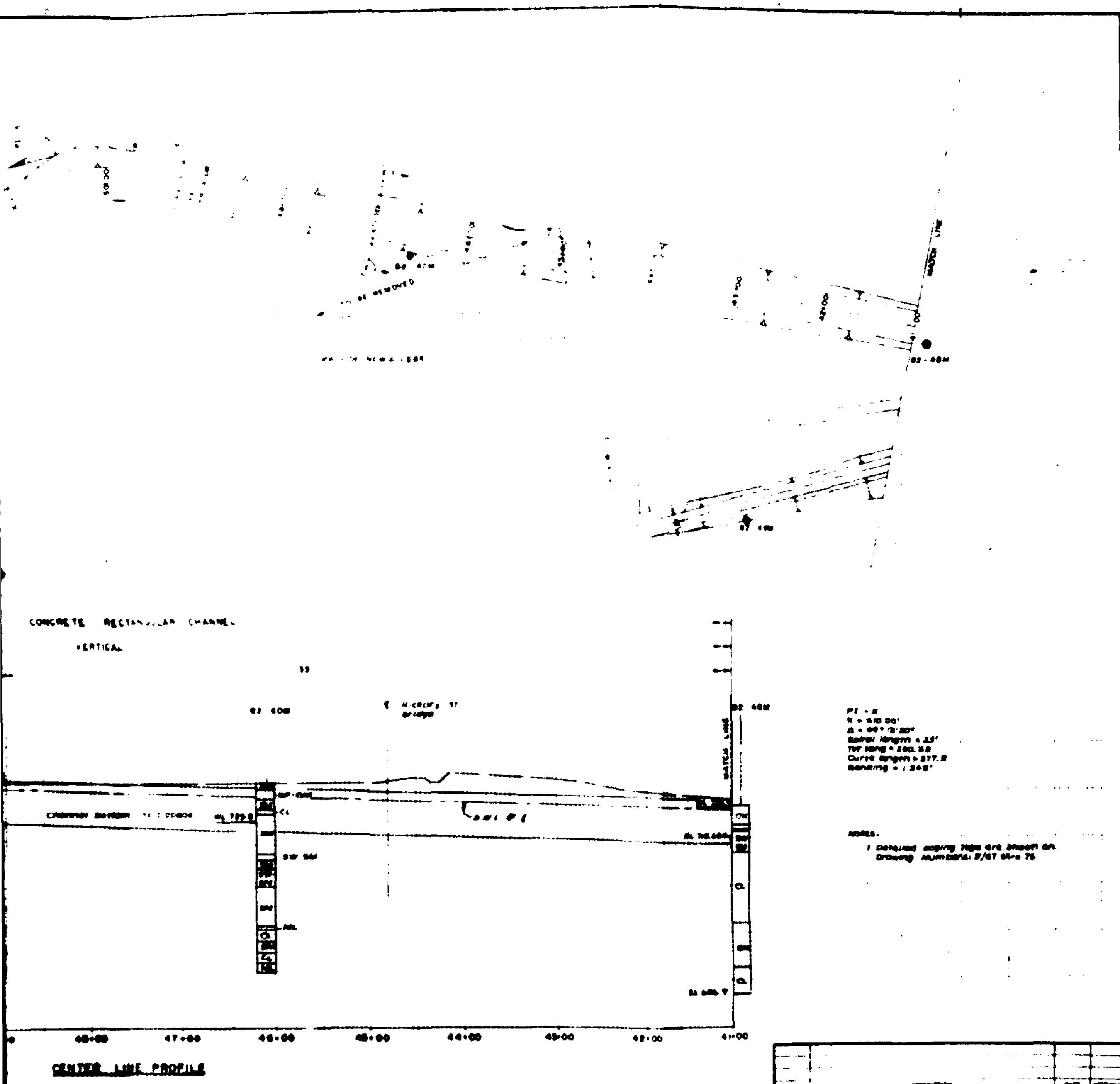
SURFACE
SIDE SLOPE
BOTTOM WIDTH
CONCRETE RECTANGULAR CHANNEL
VERTICAL
Existing ground
Top of structure
Channel bottom
CENTER LINE PROFILE
SECTION D-D



RECTANGULAR CHANNEL
CATCH BASIN
OUTLET A
SAFETY GUARD ON OUTLET
Railroad Tracks
1st Street
PROFILE
SECTION C-C
SAFETY PAYS
FLOOD CONTROL
DESIGN MEMORANDUM
CHASKA, MINNESOTA
CHASKA CREEK
PLAN & PROFILE
MARCH 1984
M 54-CH-9-5/43

PLATE 10


SURFACE
SIDE SLOPE
BOTTOM WIDTH
CONCRETE RECTANGULAR CHANNEL
VERTICAL
CENTER LINE PROFILE
SECTION E-E



FLOOD CONTROL

DESIGN MEMORANDUM

CHASKA, MINNESOTA

CHASKA CREEK

PLAN & PROFILE

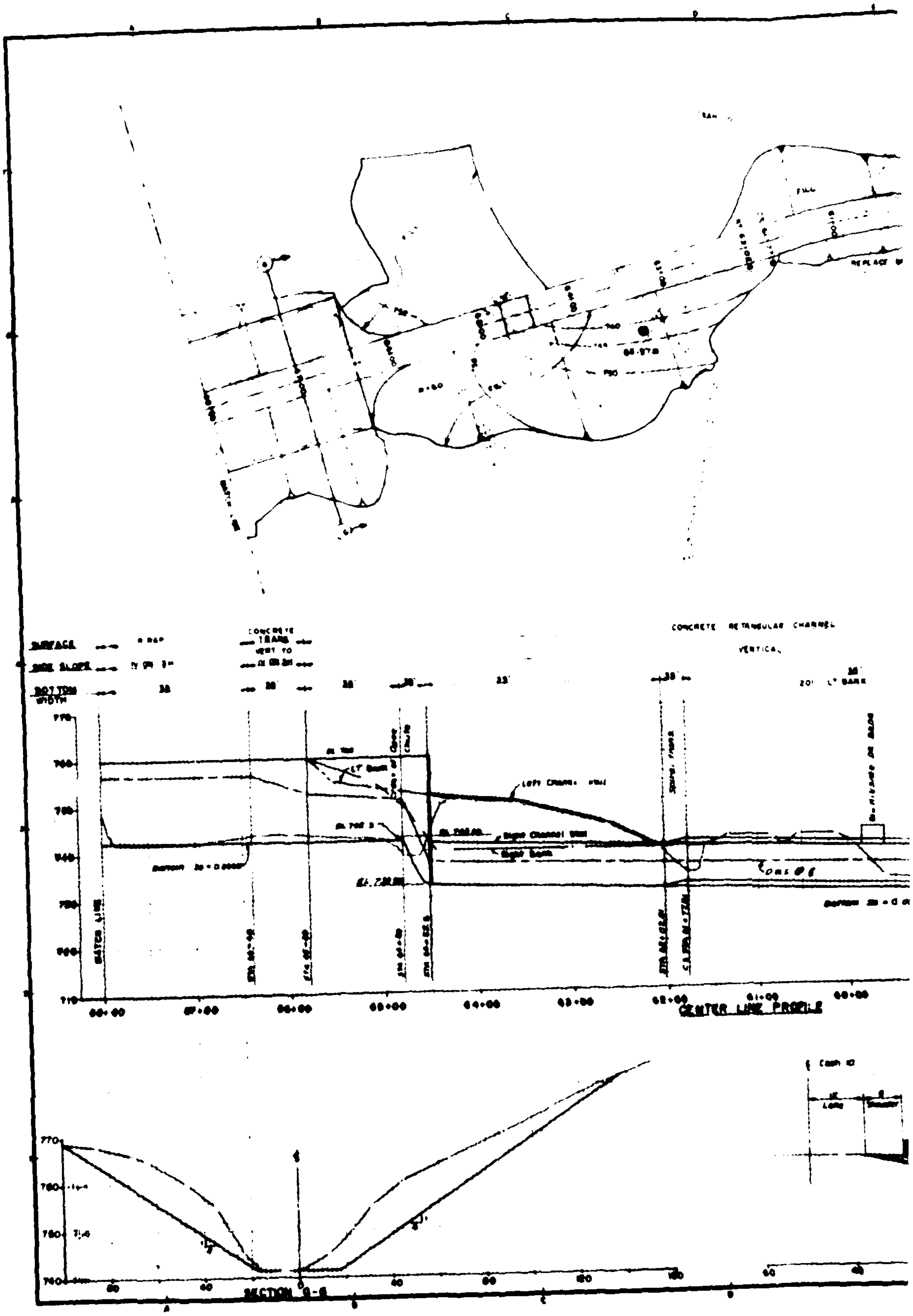
STA 41+00 TO 56+00

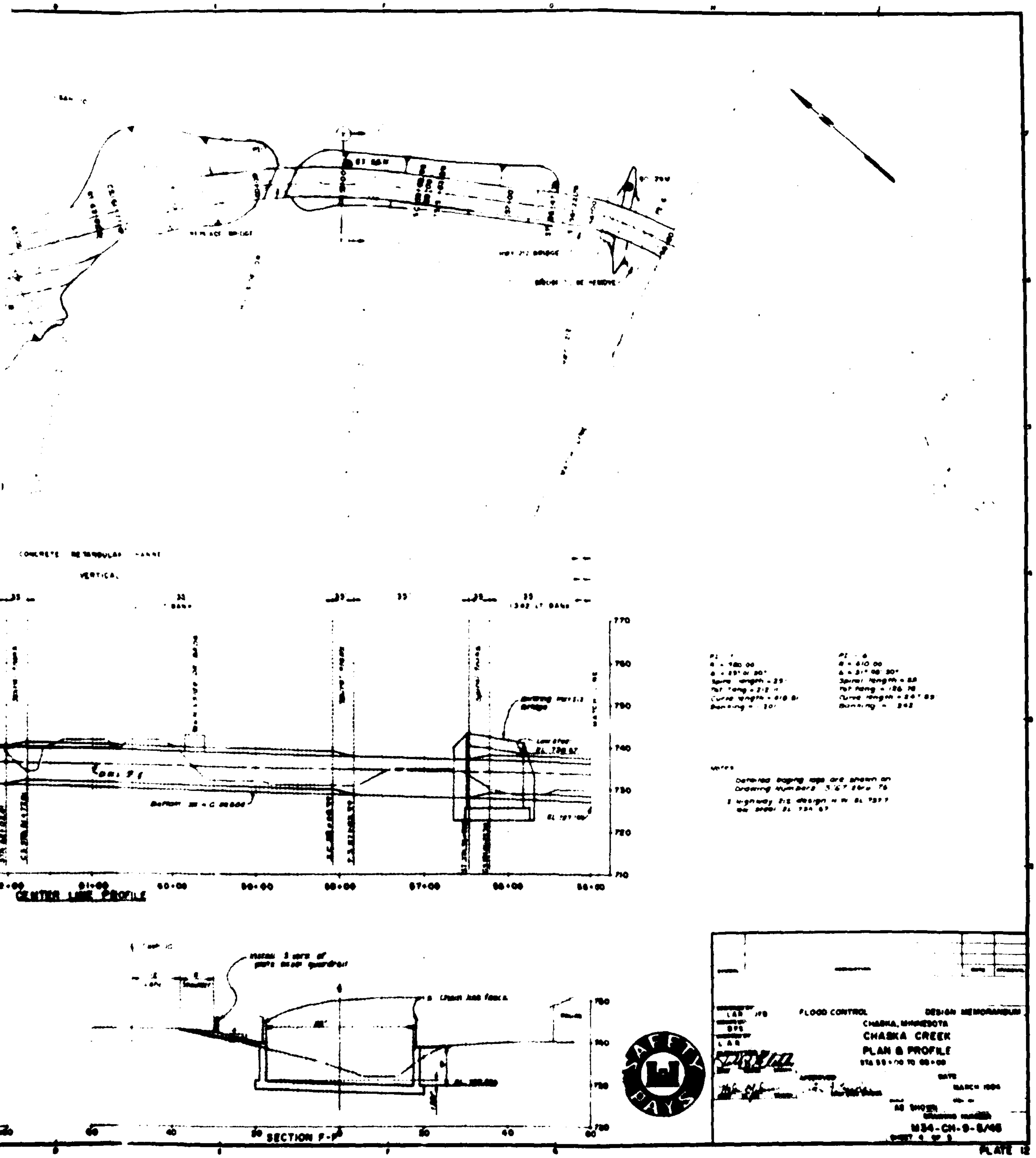
MARCH 1984

AS SHOWN

M34-CH-9-8/44

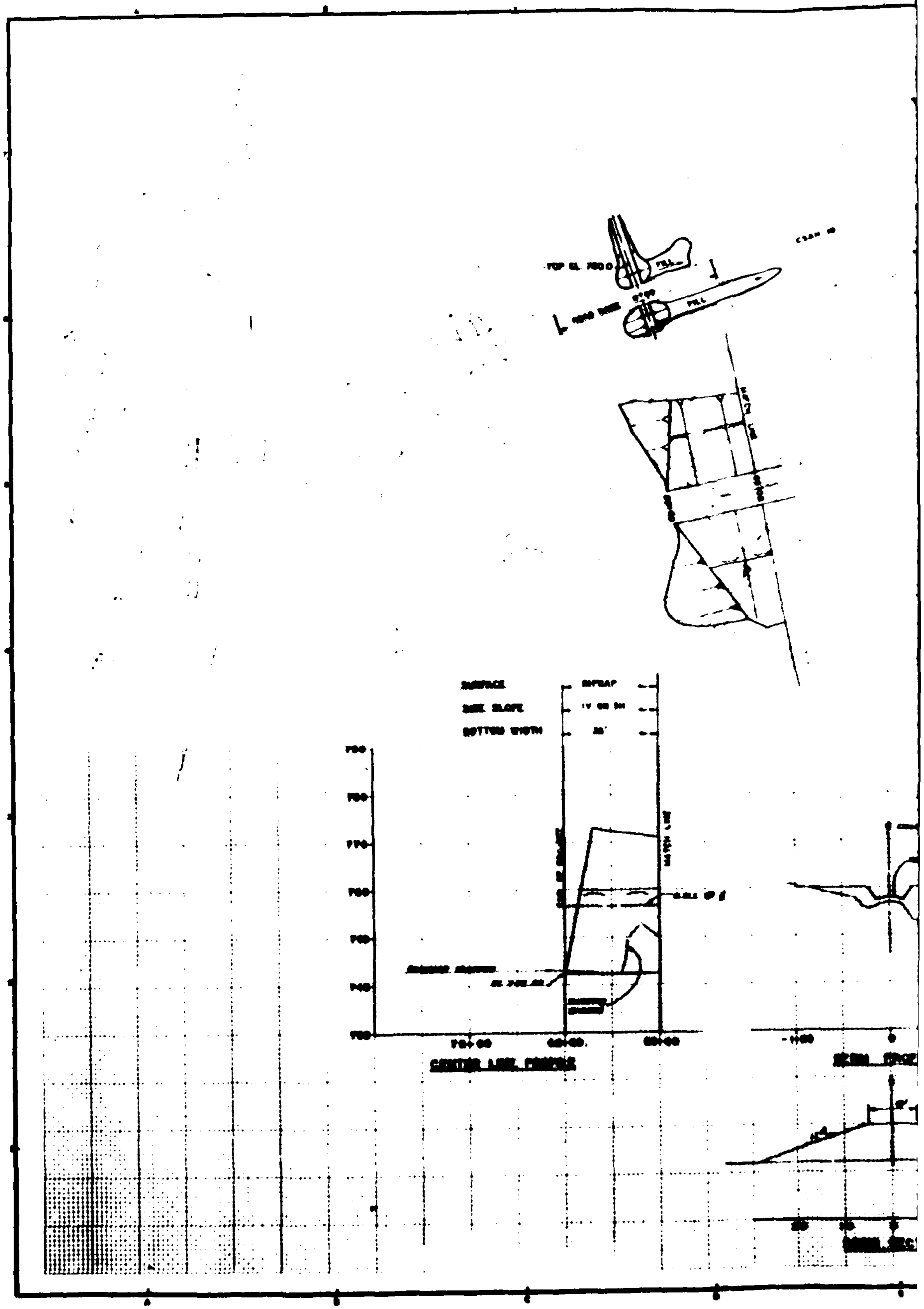
PLATE 11


CONCRETE RETANGULAR CHANNEL
VERTICAL
SURFACE
SIDE SLOPE
BOTTOM WIDTH
CENTER LINE PROFILE
SECTION G-G

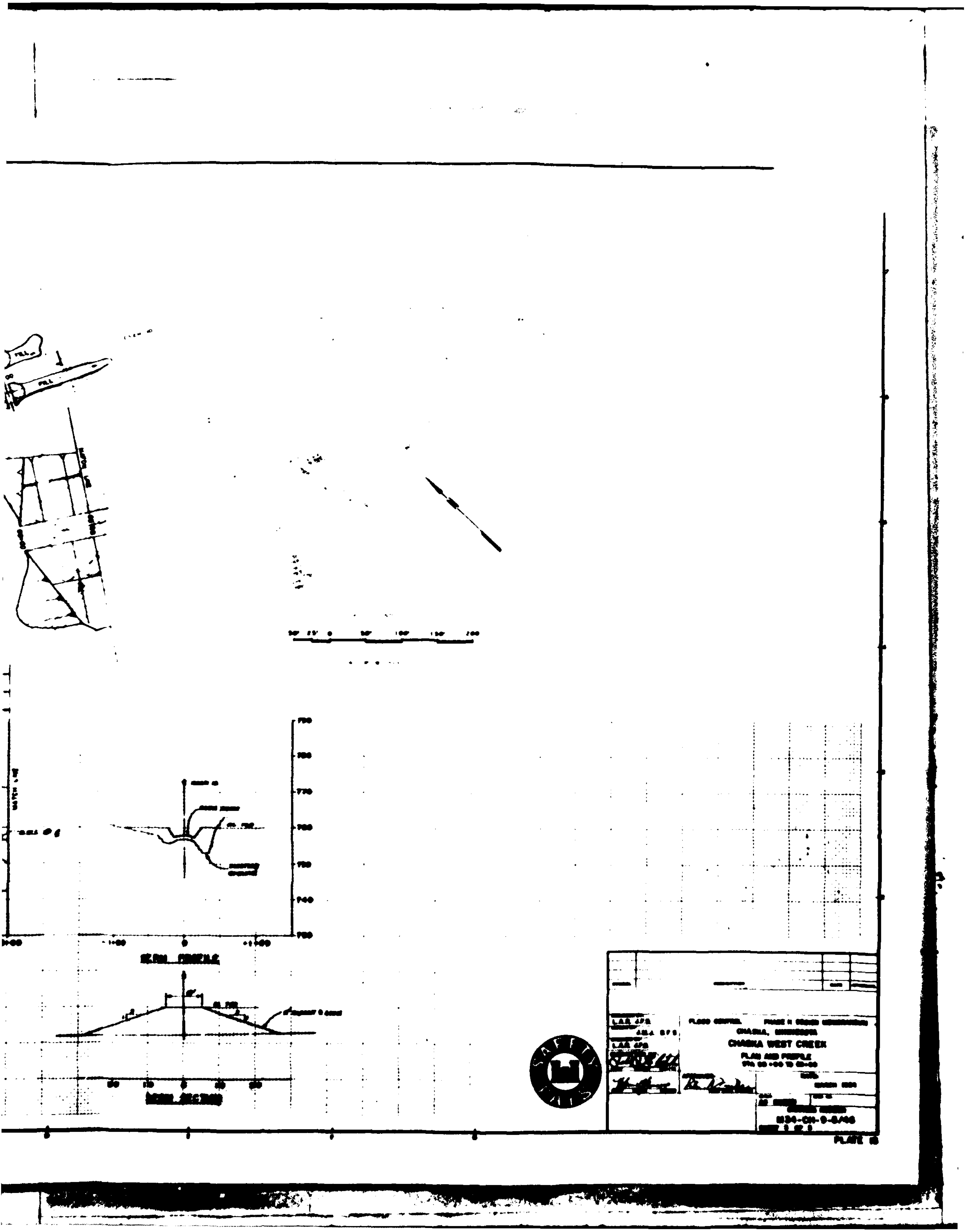


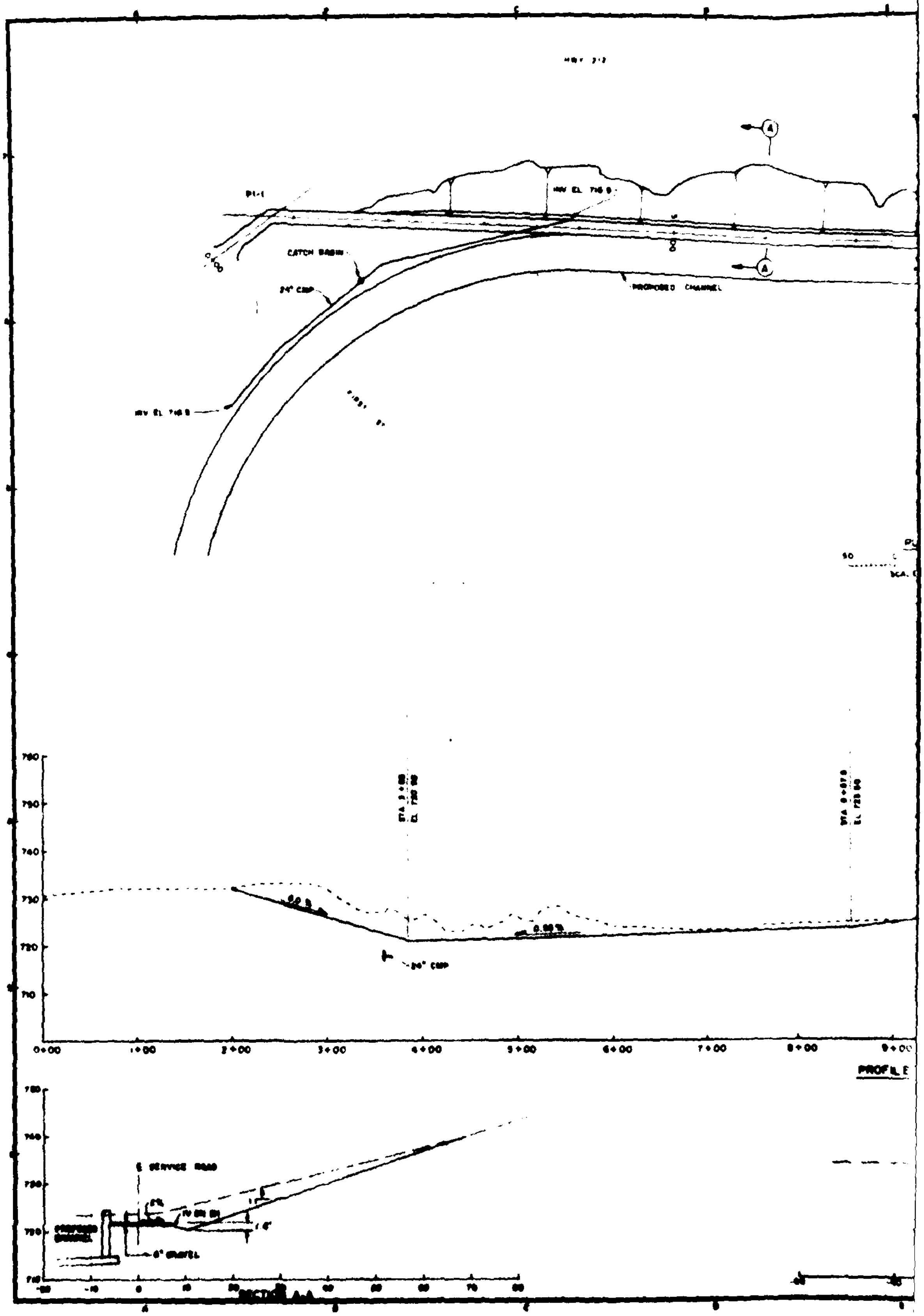
CENTER LINE PROFILE
SECTION F-F
FLOOD CONTROL
DESIGN MEMORANDUM
CHASKA, MINNESOTA
CHASKA CREEK
PLAN & PROFILE
AS SHOWN

PLATE 12

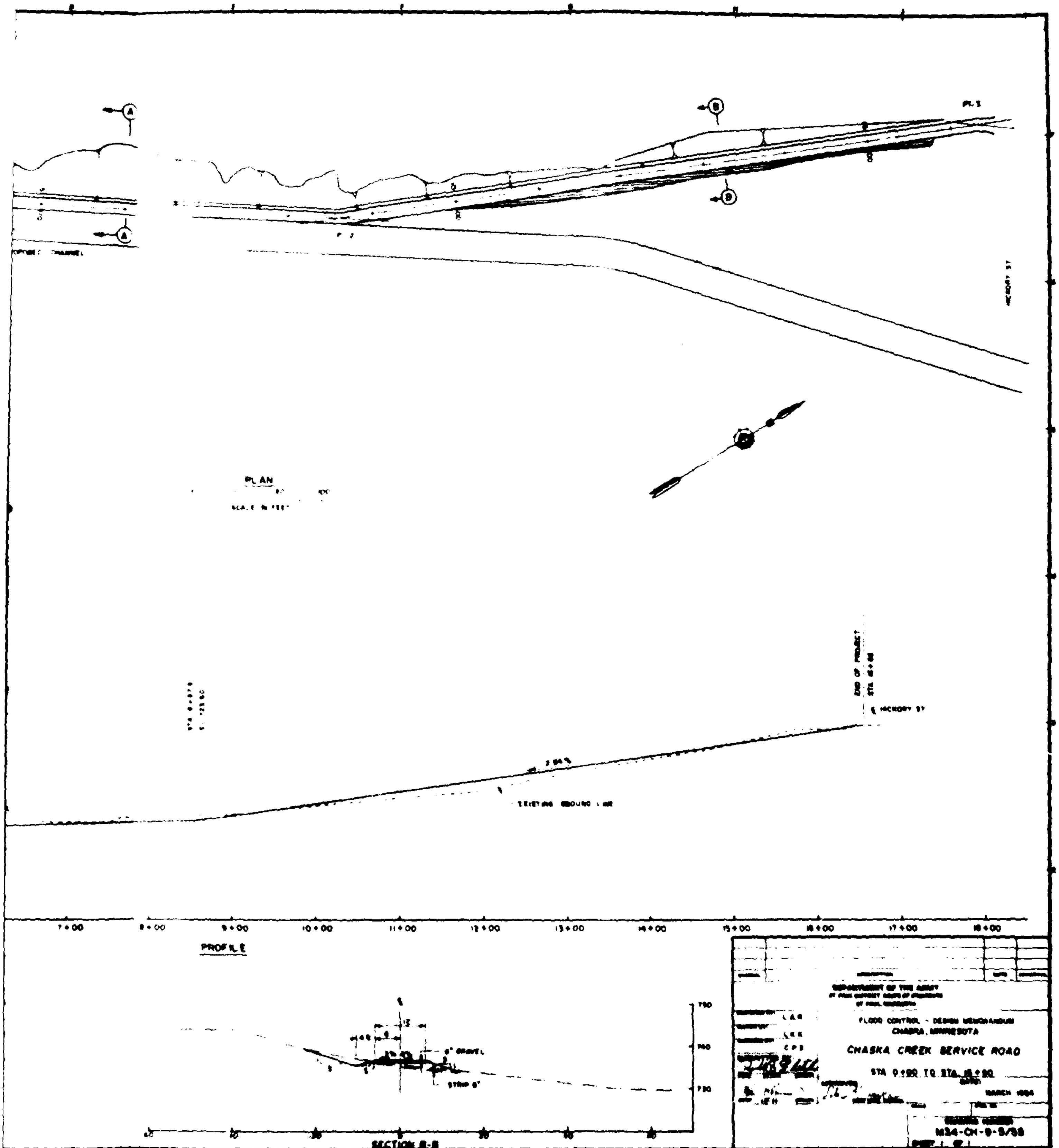


SURFACE
SIDE SLOPE
BOTTOM WIDTH
MATCH LINE
CENTER LINE PROFILE


FILL
FLOOD CONTROL
CHASKA WEST CREEK
PLAN AND PROFILE

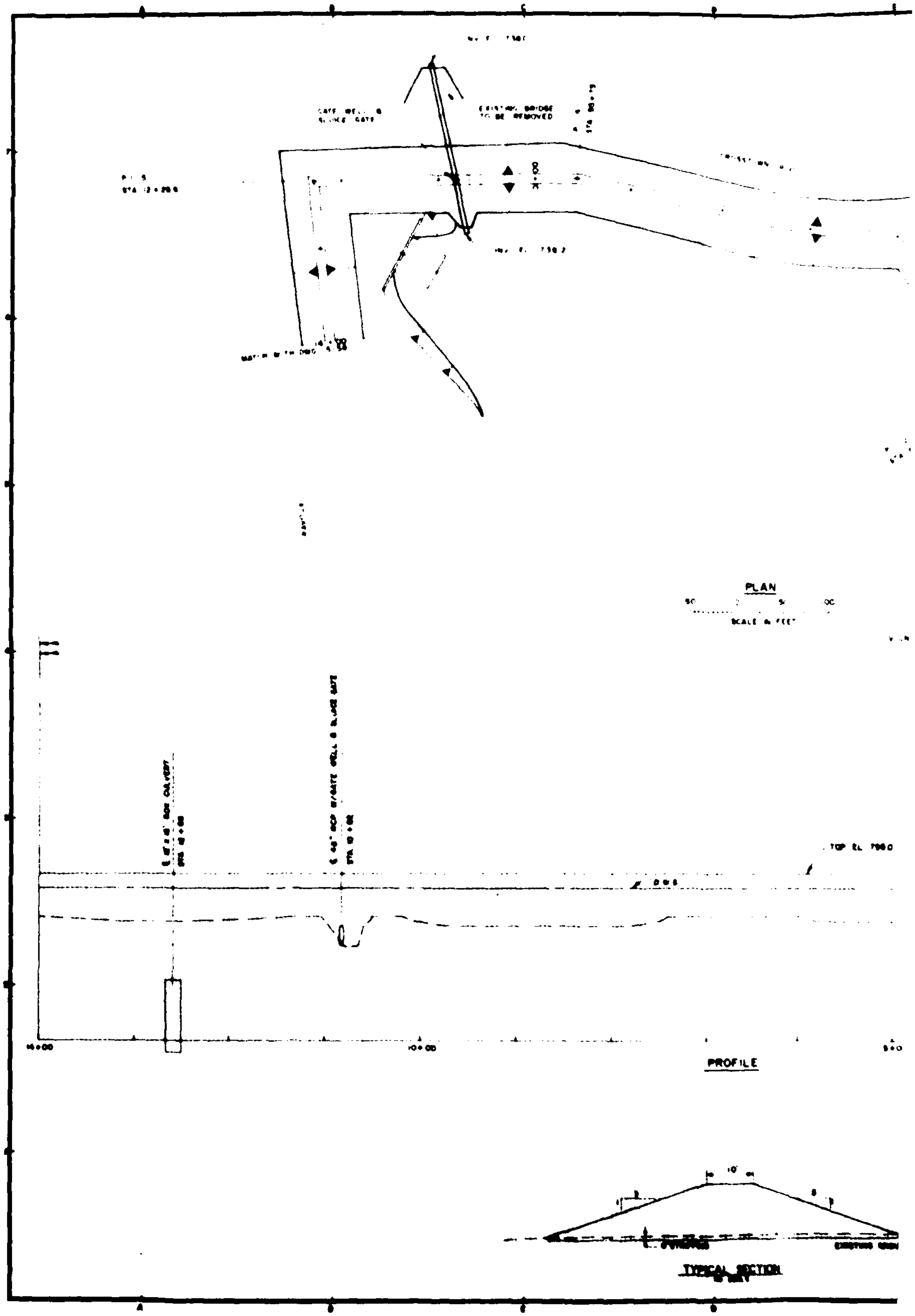


CATCH BASIN
24" CMP
PROPOSED CHANNEL
24" CMP
PROFILE
SERVICE ROAD
8" GRAVEL
SECTION A-A



PLAN
SCALE IN FEET
HICKORY ST
END OF PROJECT
EXISTING GROUND LINE
PROFILE
7+00
8+00
9+00
10+00
11+00
12+00
13+00
14+00
15+00
16+00
17+00
18+00
6" GRAVEL
STRIP 6"
SECTION B-B
FLOOD CONTROL - DESIGN MEMORANDUM
CHASKA, MINNESOTA
CHASKA CREEK SERVICE ROAD
STA 0+00 TO STA 18+80
M34-CH-9-5/88

PLATE 14


EXISTING BRIDGE TO BE REMOVED
PLAN
SCALE IN FEET
PROFILE
TYPICAL SECTION

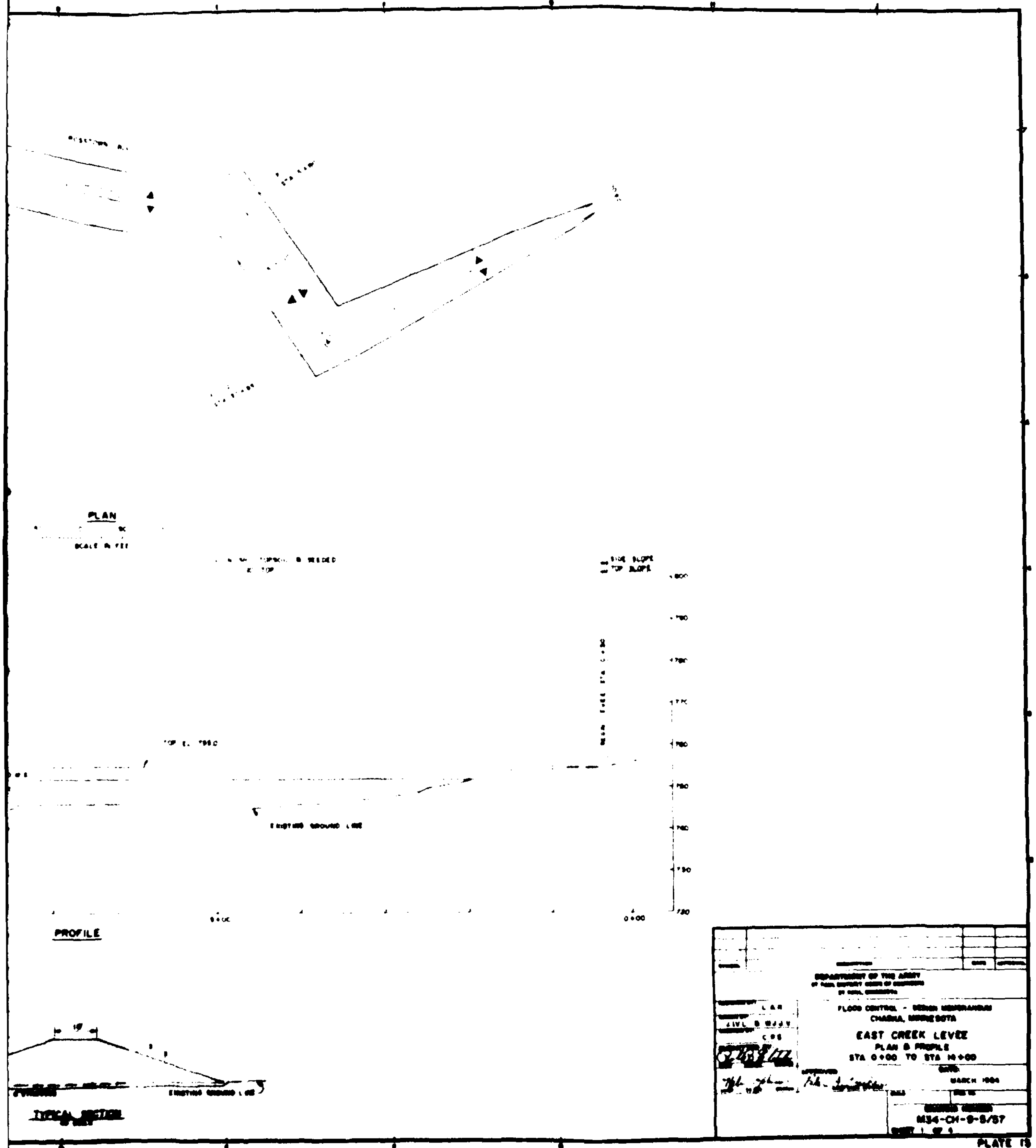
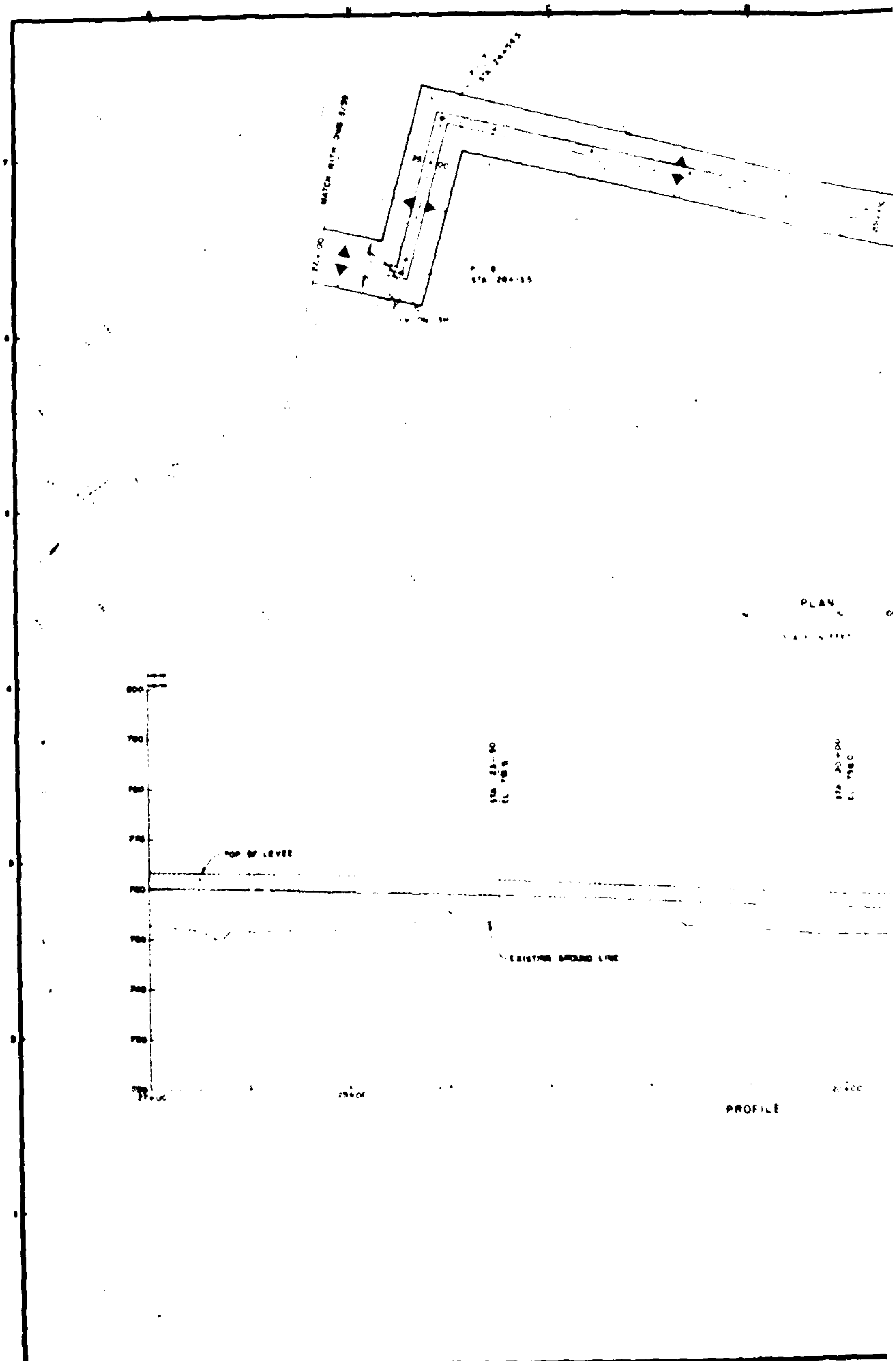
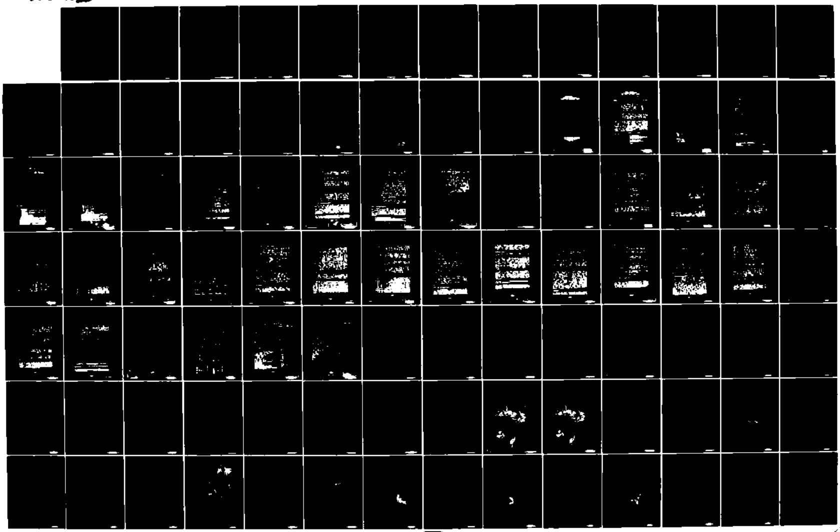

PLAN
PROFILE
EXISTING GROUND LINE
TYPICAL SECTION
DEPARTMENT OF THE ARMY
FLOOD CONTROL - DESIGN MEMORANDUM
CHASKA, MINNESOTA
EAST CREEK LEVEE
PLAN & PROFILE
STA 0+00 TO STA 14+00
MARCH 1964
M34-CH-9-S/57

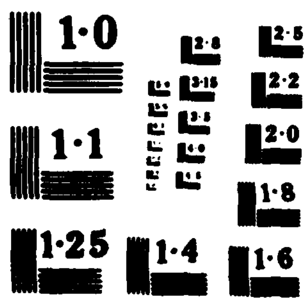
PLATE 13

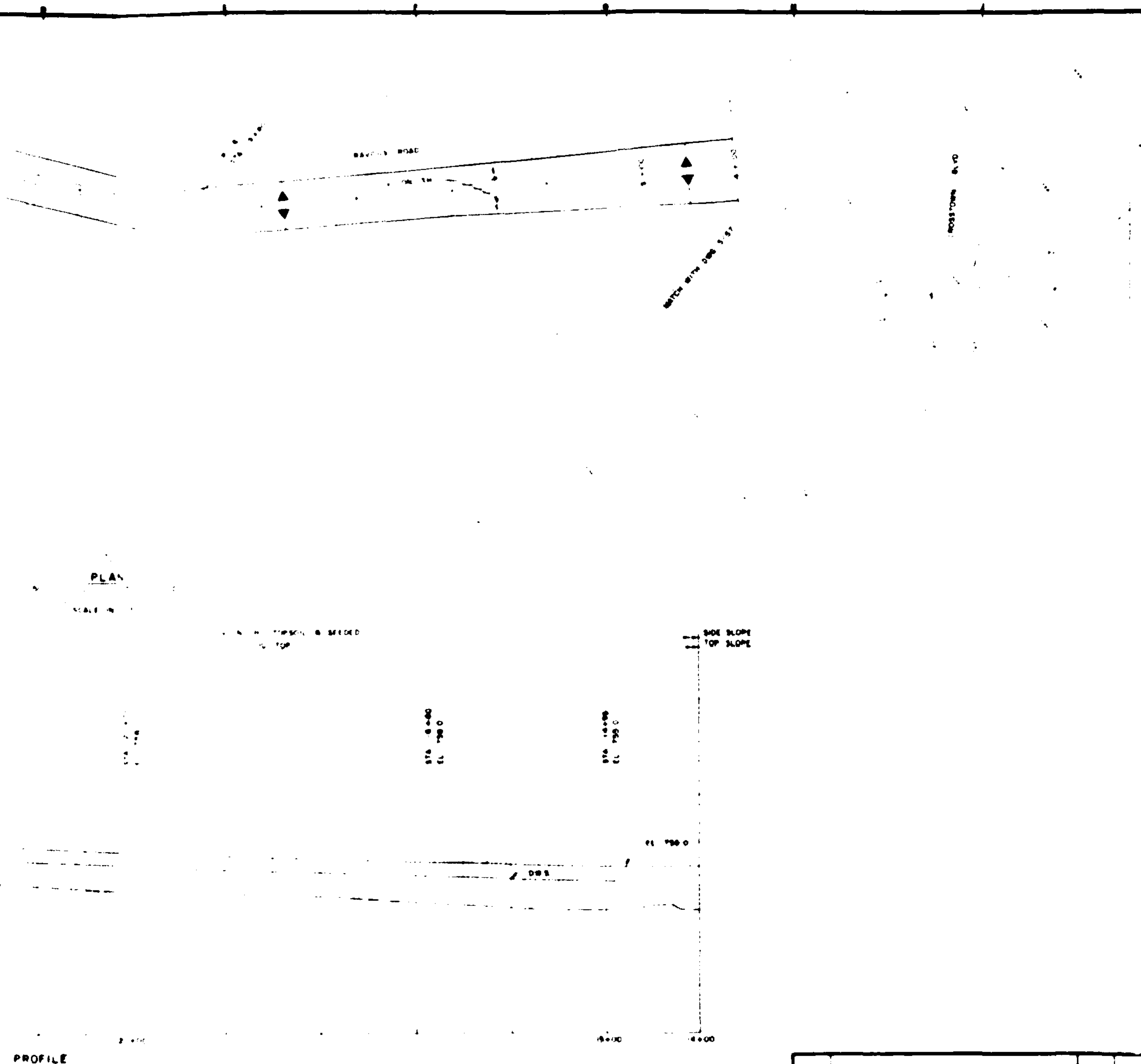

PLAN
TOP OF LEVEE
EXISTING GROUND LINE
PROFILE

AD-A146 795 MINNESOTA RIVER AT CHASKA MINNESOTA FLOOD CONTROL PROJECT GENERAL DESIGN..(U) CORPS OF ENGINEERS ST PAUL MN ST PAUL DISTRICT AUG 84 2/6

UNCLASSIFIED F/G 13/2 NL




1·0
2·8
2·5
3·15
2·2
1·1
2·0
1·8
1·25
1·4
1·6

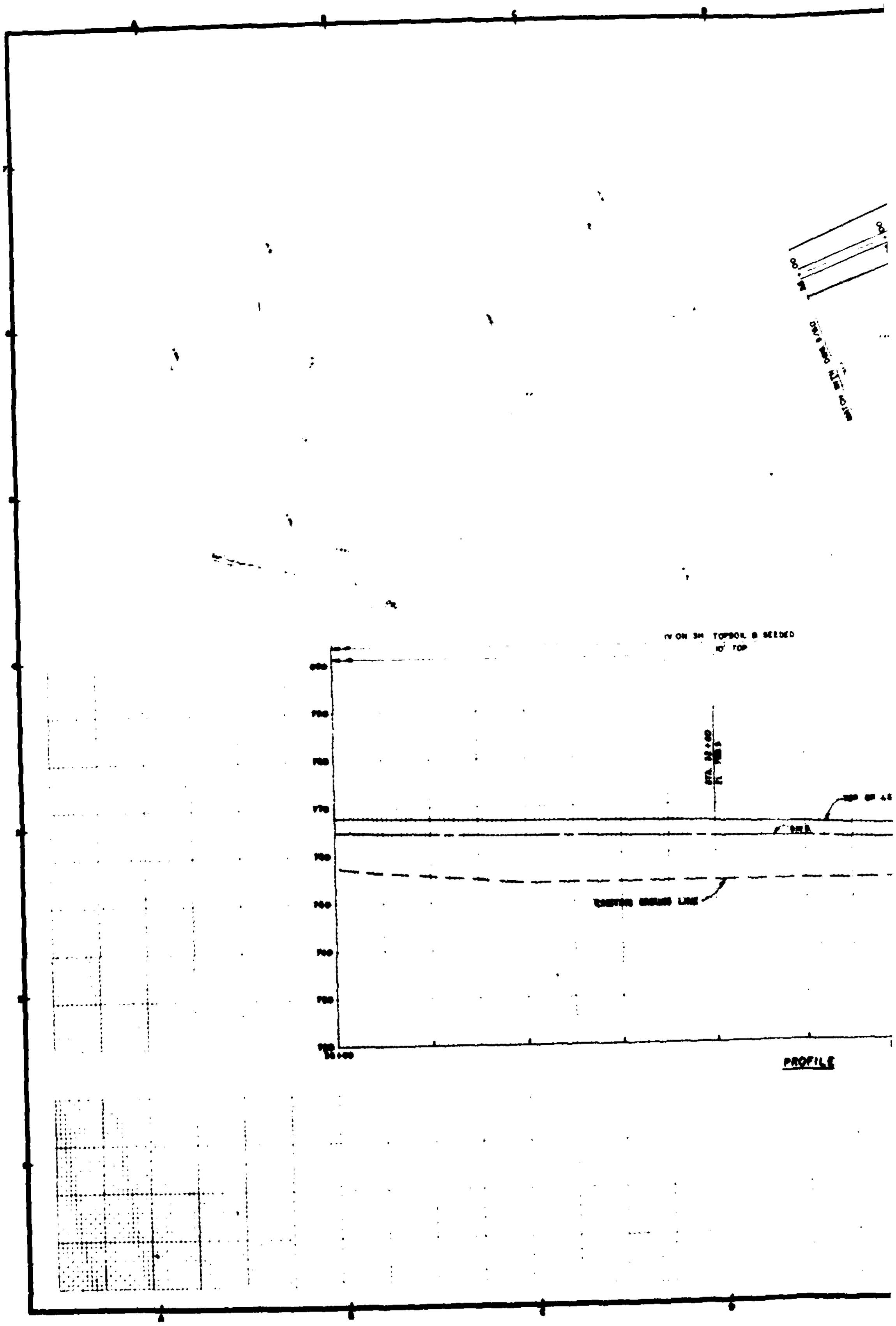


FLOOD CONTROL - DESIGN MEMORANDUM
CHASKA, MINNESOTA

EAST CREEK LEVEE
PLAN & PROFILE
STA 16+00 TO STA 27+00

MARCH 1984

M34-CH-9-5/56



TOPSOIL & SEEDED
10' TOP
PROFILE

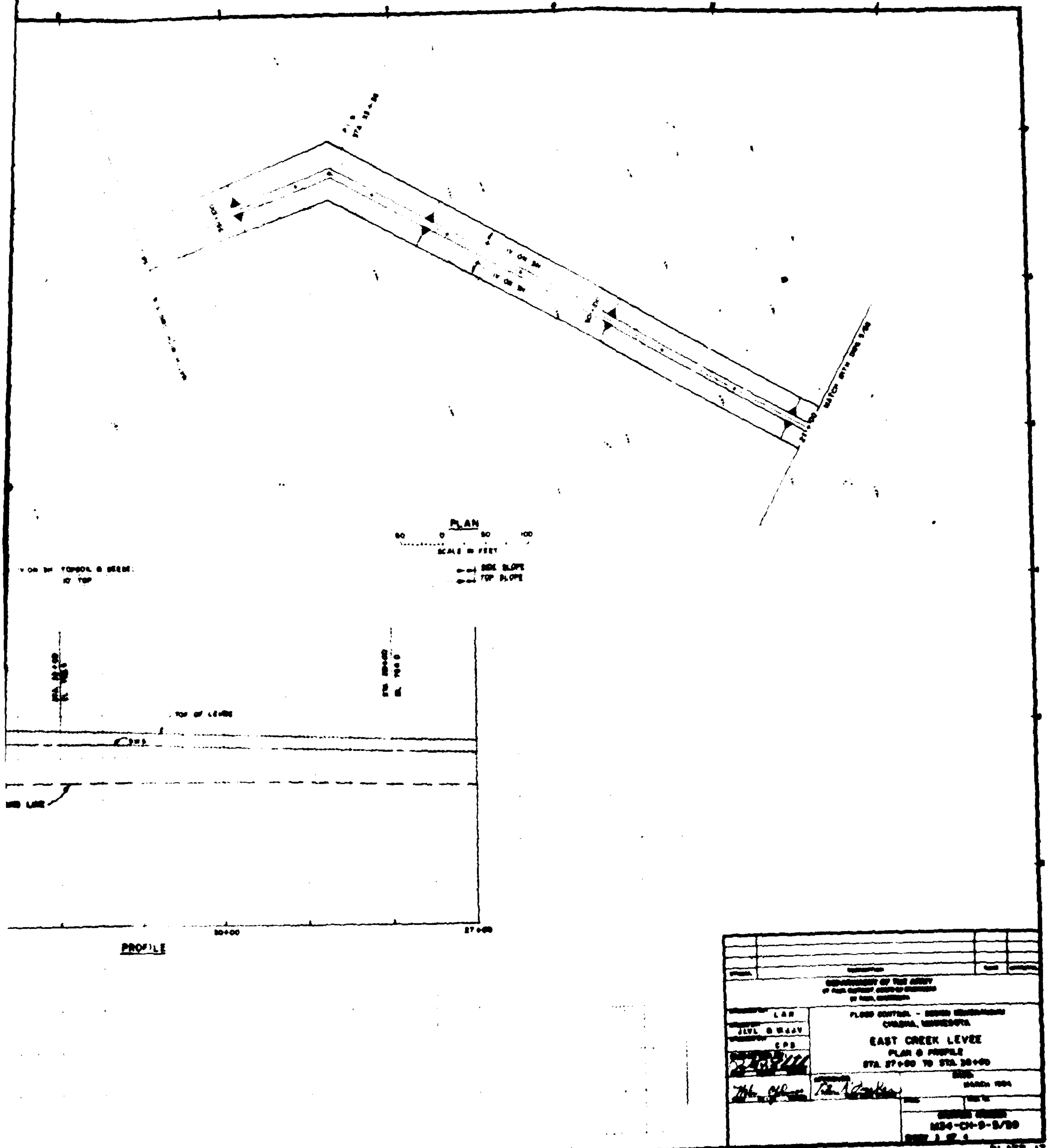
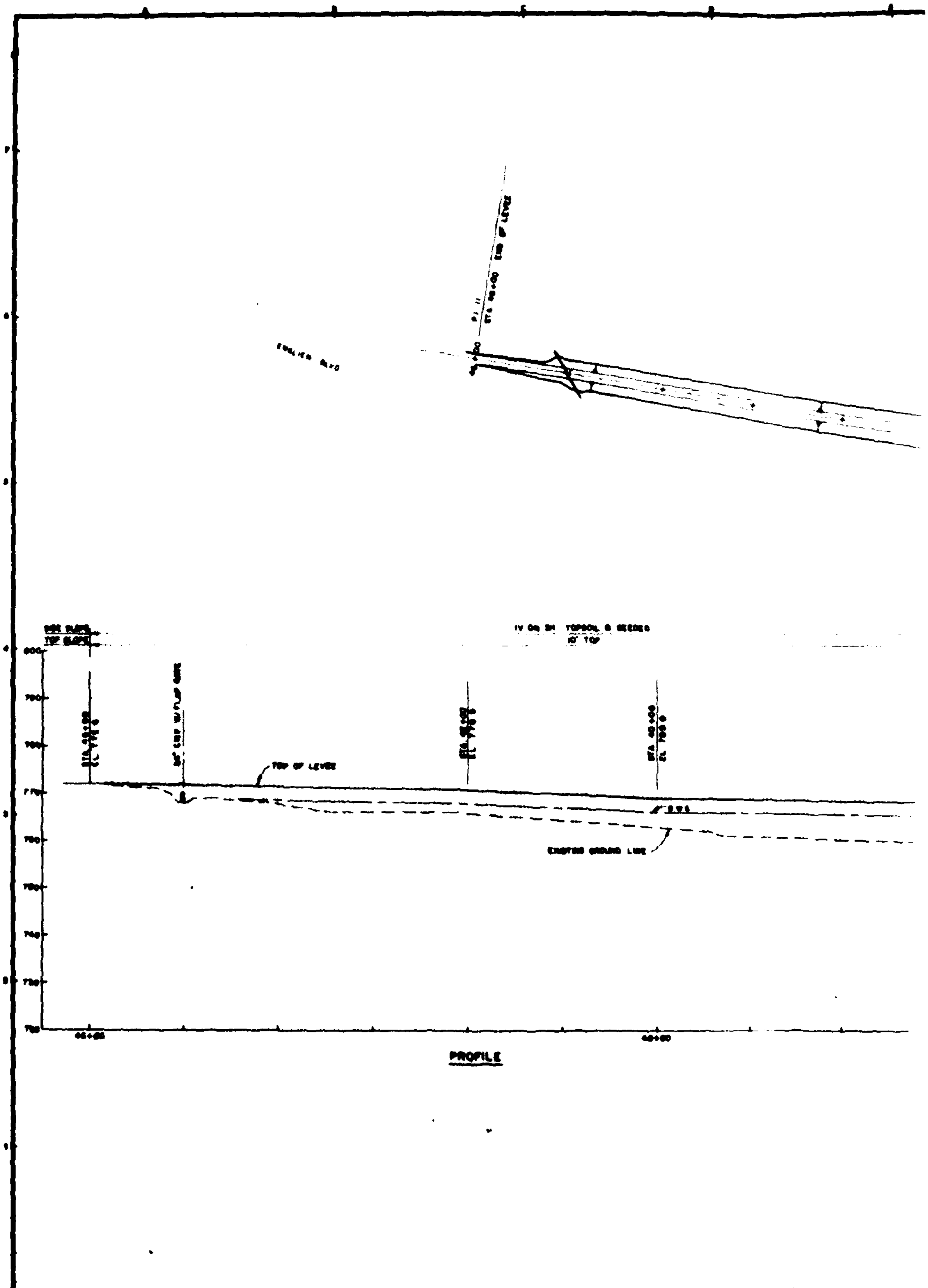
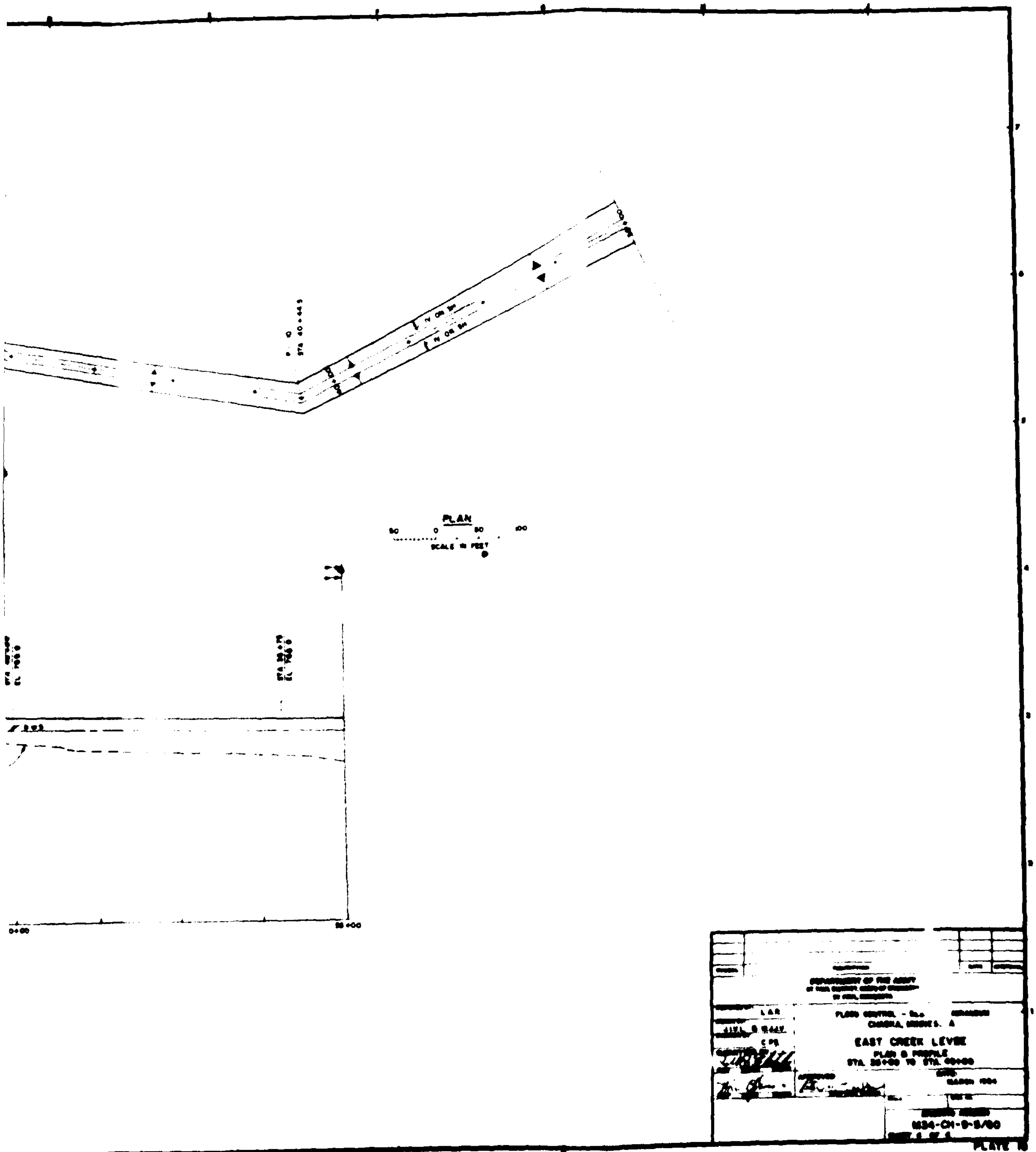

PLAN
SCALE IN FEET
SIDE SLOPE
TOP SLOPE
TOP OF LEVEE
PROFILE
30+00
27+00
EAST CREEK LEVEE
PLAN & PROFILE
MARCH 1984

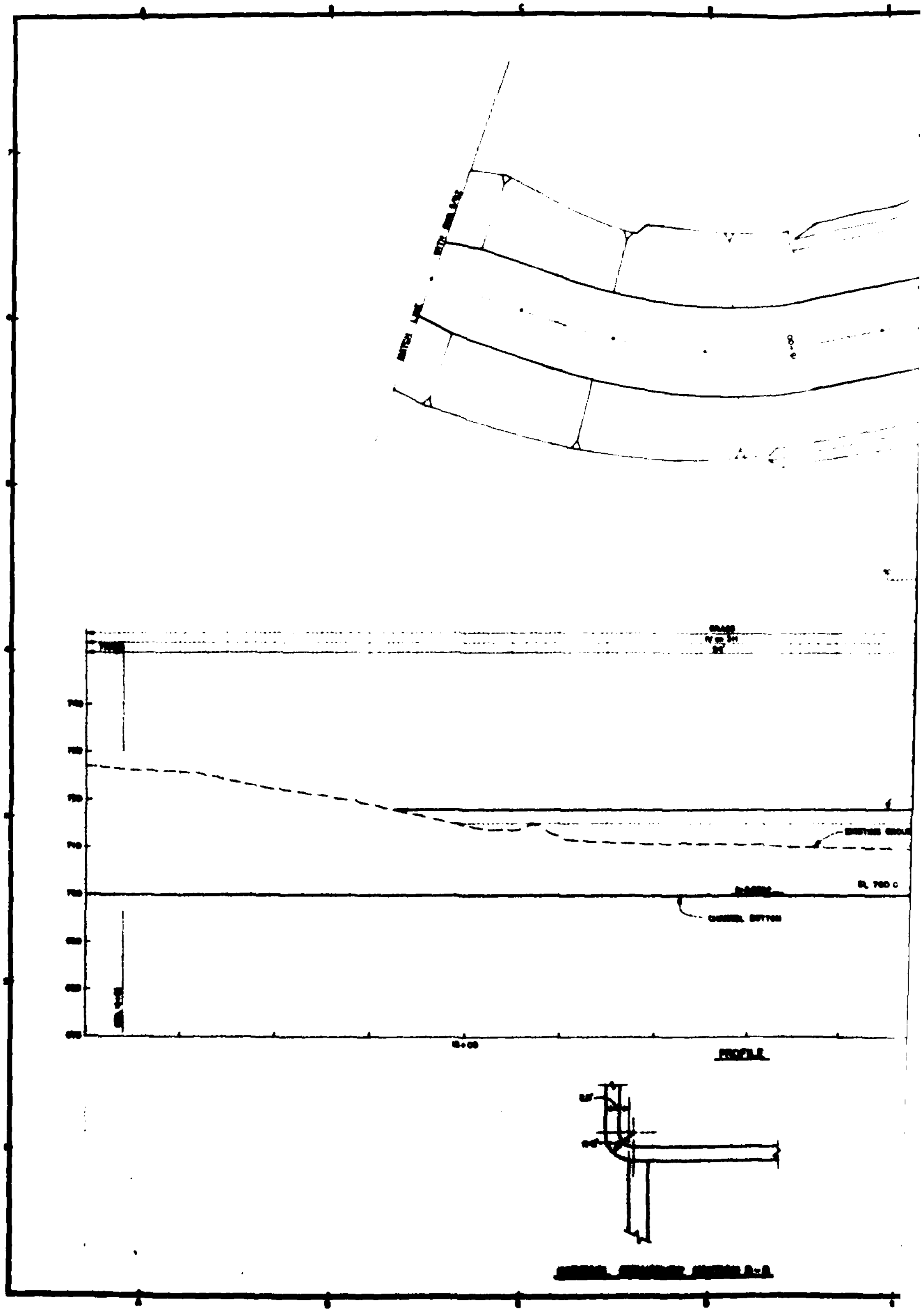
PLATE 17


END OF LEVEE
TOP OF LEVEE
EXISTING GROUND LINE
10' TOP
800
770
730

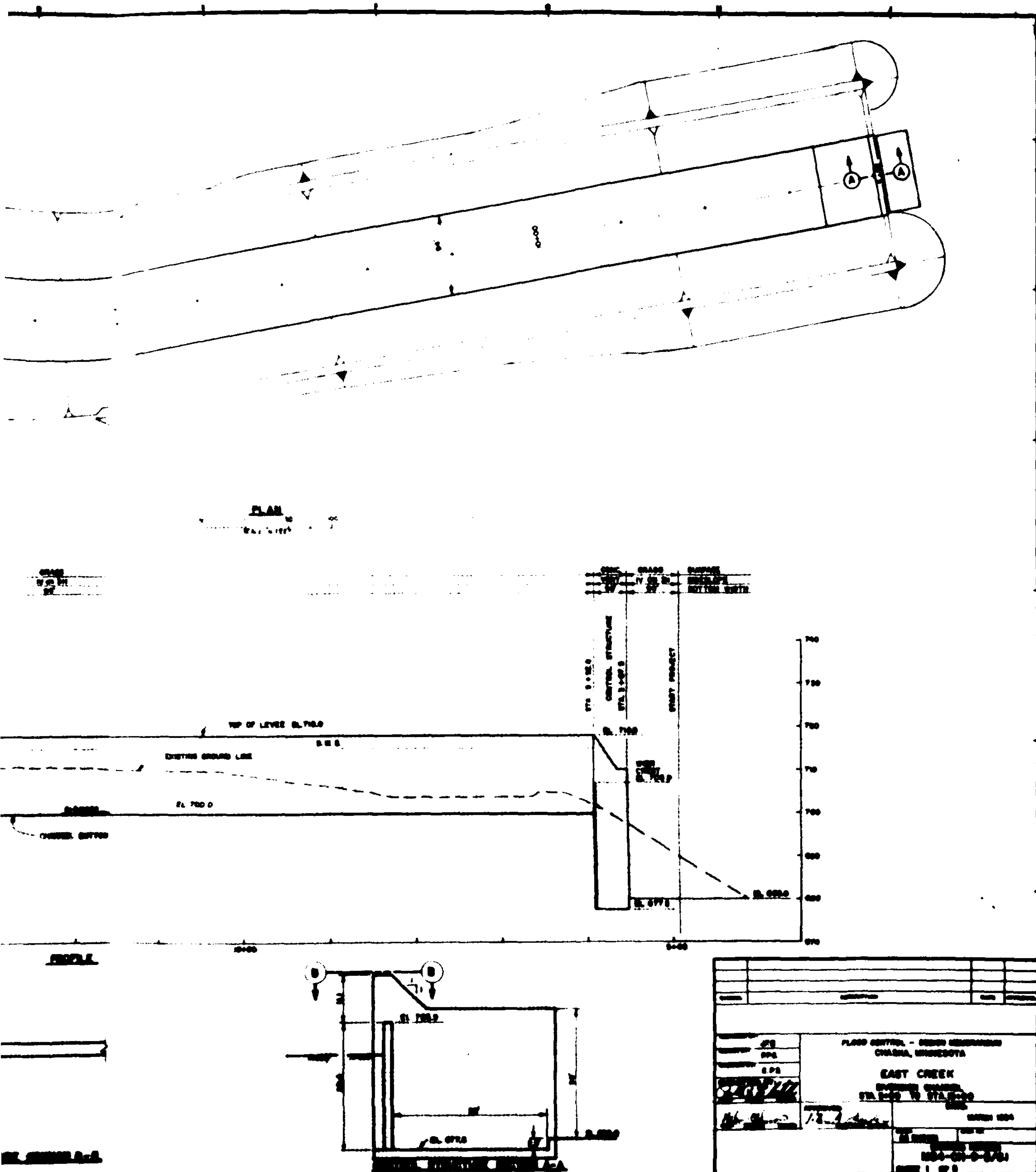
PROFILE



STA 40+44.5
PLAN
SCALE IN FEET
30+00
DEPARTMENT OF THE ARMY
EAST CREEK LEVEE
PLAN & PROFILE
MARCH 1964
PLATE 16

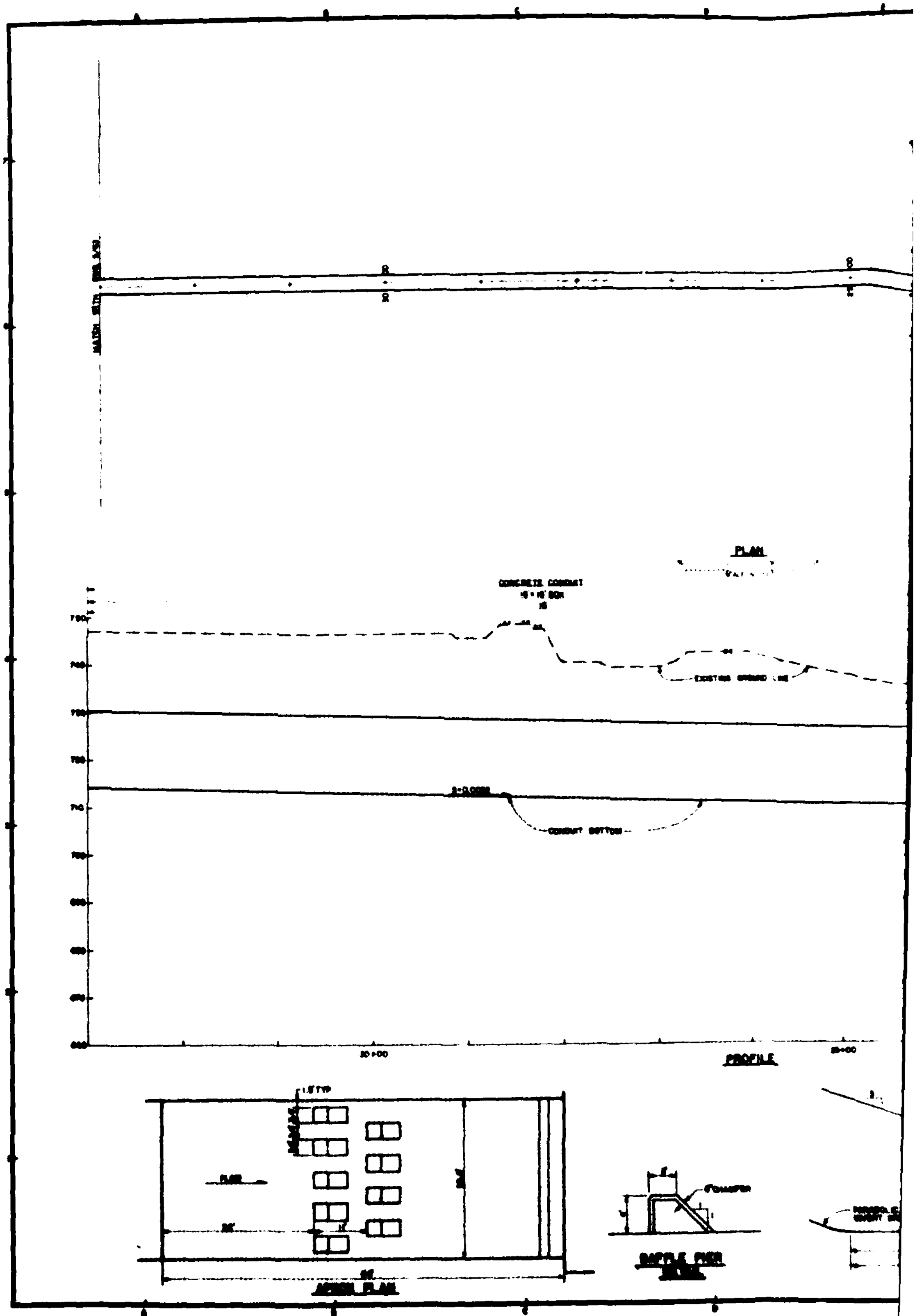


10+00
PROFILE



PLAN
TOP OF LEVEE EL 710.0
EXISTING GROUND LINE
EL 700.0
CHANNEL BOTTOM
CONTROL STRUCTURE
DRAFT PROJECT
EL 710.0
WEIR CREST
PROFILE
EL 700.0
CONTROL STRUCTURE SECTION A-A
EAST CREEK
CHASKA, MINNESOTA

PLATE 10



PLAN
CONCRETE CONDUIT
EXISTING GROUND LINE
CONDUIT BOTTOM
PROFILE
1.5' TYP
APRON PLAN
BAFFLE PIER

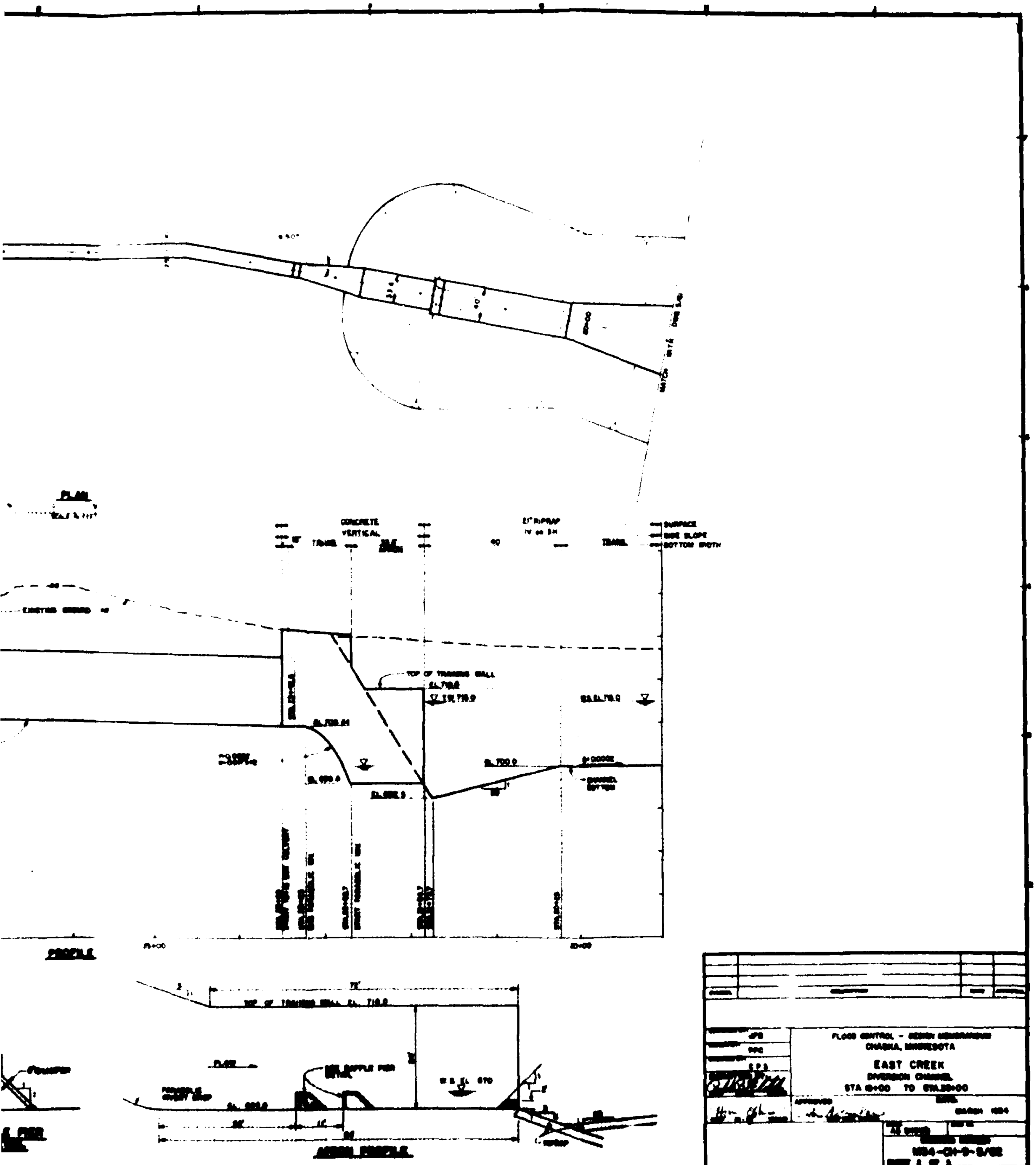
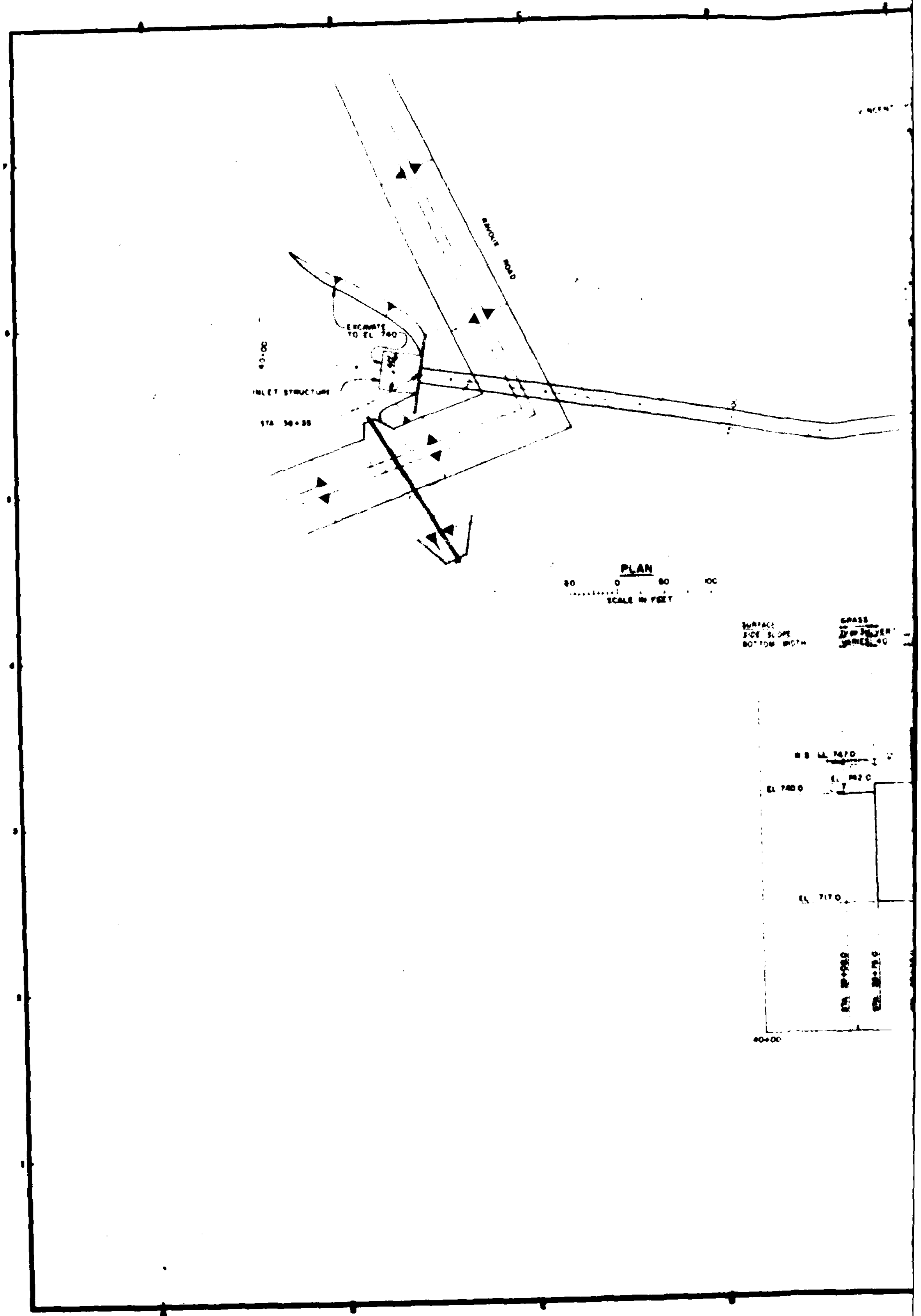
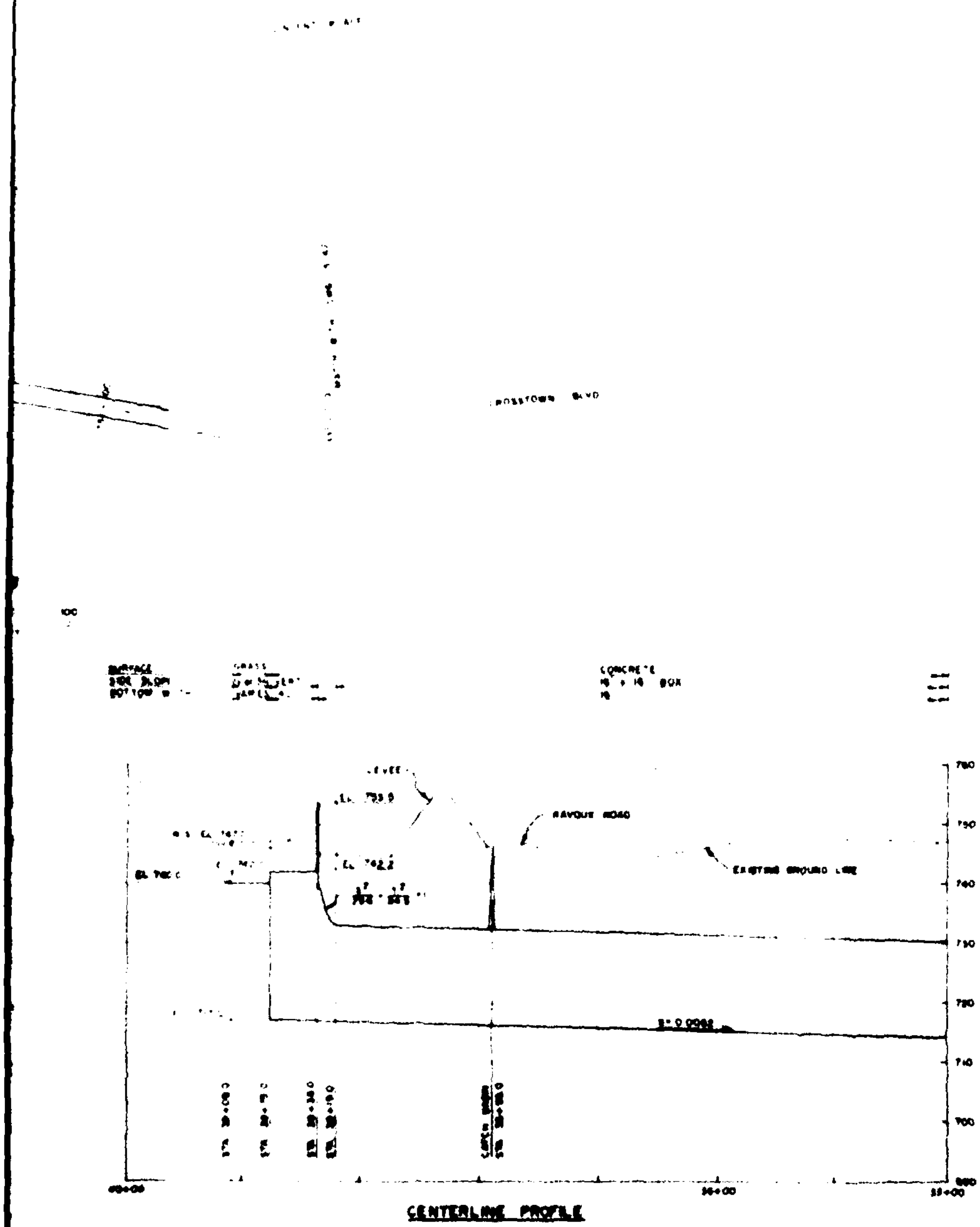

PLAN
CONCRETE VERTICAL
TRANS.
21" RIPRAP 1V on 3H
SURFACE
SIDE SLOPE
BOTTOM WIDTH
EXISTING GROUND
TOP OF TRAINING WALL EL.719.0
EL.700.0
PROFILE
TOP OF TRAINING WALL EL. 719.0
W.S. EL. 670
APRON PROFILE
FLOOD CONTROL - DESIGN MEMORANDUM
CHASKA, MINNESOTA
EAST CREEK
DIVERSION CHANNEL

PLATE 20


EXCAVATE TO EL 740
INLET STRUCTURE
ROAD
PLAN
SCALE IN FEET
SURFACE
SIDE SLOPE
BOTTOM WIDTH
GRASS
EL 740.0
EL 717.0



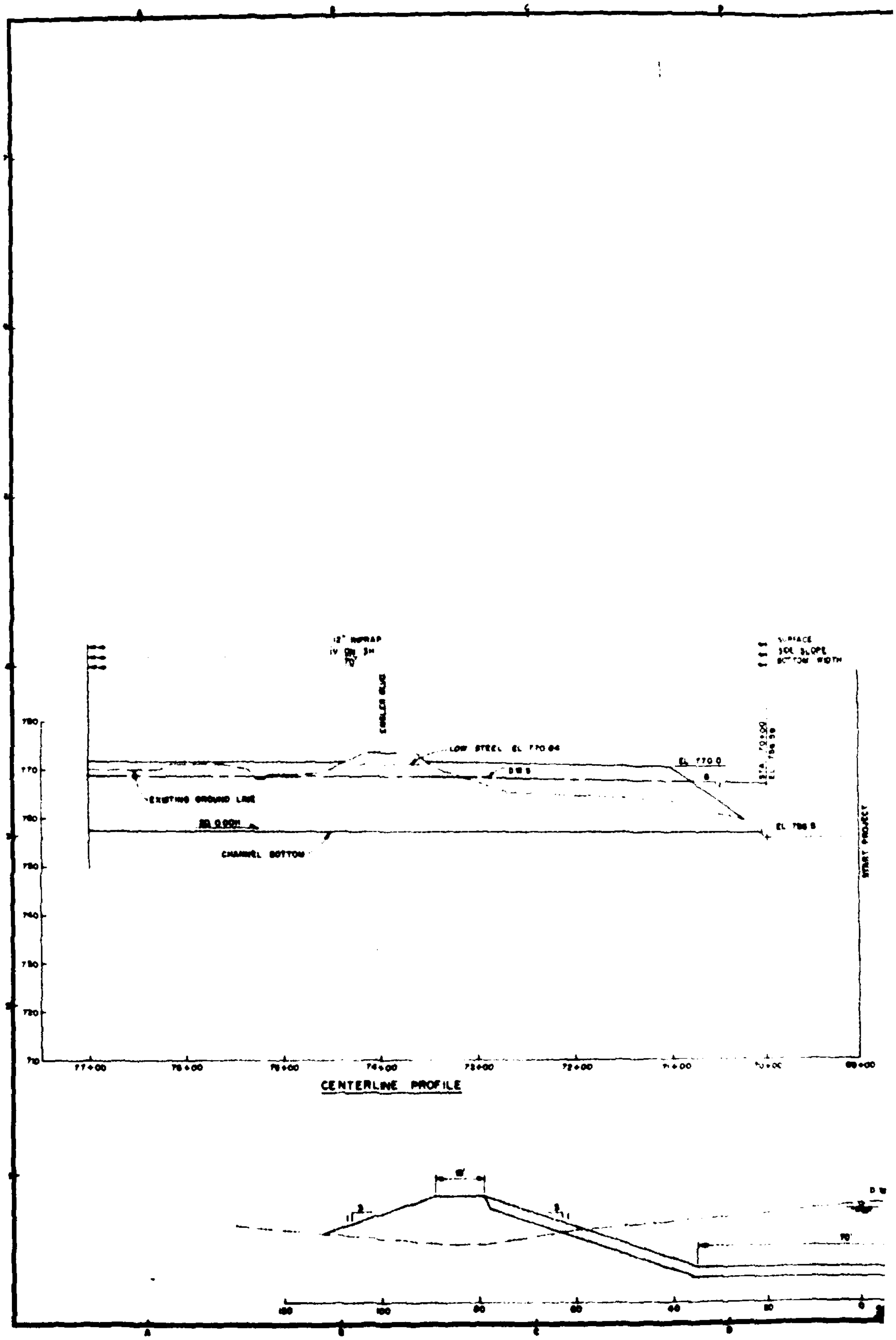
FLOOD CONTROL - DESIGN MEMORANDUM
CHASKA, MINNESOTA

EAST CREEK
DIVERSION CHANNEL
STA 30+00 TO STA 36+00

MARCH 84

M34-CH-9-6/63

PLATE 31


12" RIPRAP
1V ON 3H
LOW STEEL EL 770.84
EL 770.0
EXISTING GROUND LINE
CHANNEL BOTTOM
EL 756.5
START PROJECT
CENTERLINE PROFILE

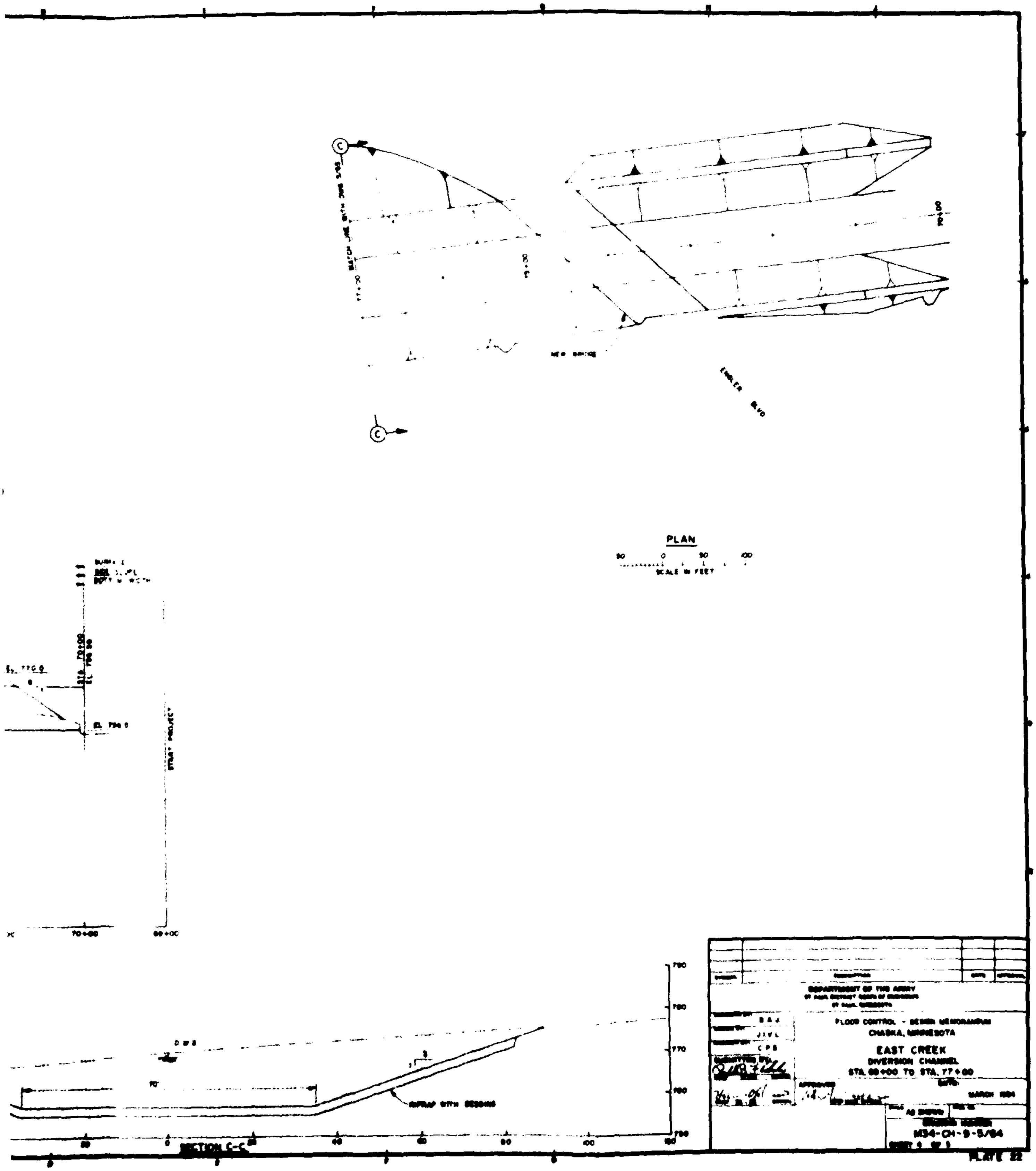
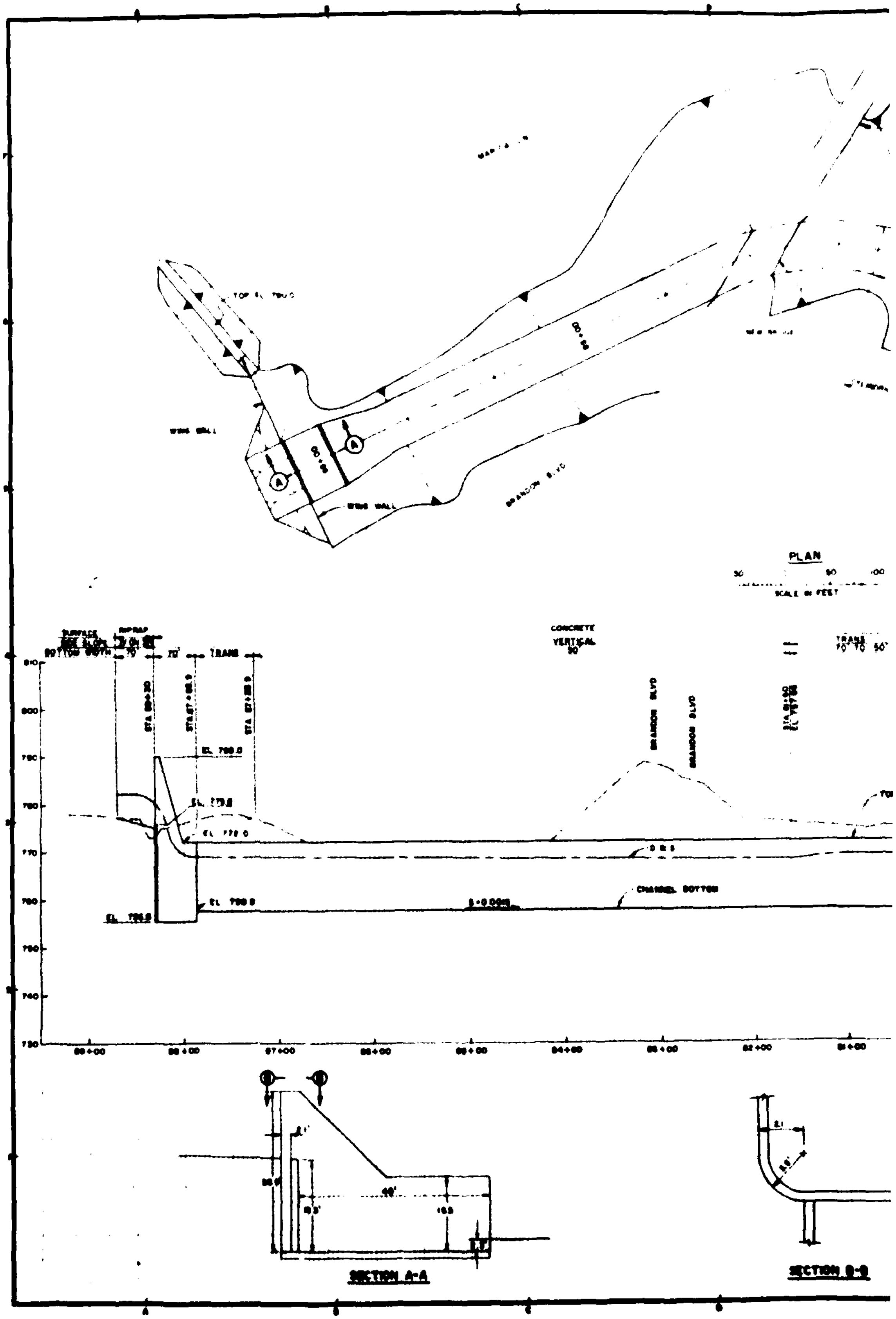

PLAN
SCALE IN FEET
NEW BRIDGE
ENGLER BLVD
EL 770.0
EL 756.0
STRAT PROJECT
70+00
69+00
SECTION C-C
RIPRAP WITH BEDDING
DEPARTMENT OF THE ARMY
FLOOD CONTROL - DESIGN MEMORANDUM
CHASKA, MINNESOTA
EAST CREEK
DIVERSION CHANNEL
STA. 69+00 TO STA. 77+00
MARCH 1984
AS SHOWN
M34-CH-9-5/84

PLATE 22



PLAN
SCALE IN FEET
WING WALL
BRANDON BLVD
CONCRETE
VERTICAL
TRANS
RIPRAP
SURFACE
BOTTOM WIDTH
CHANNEL BOTTOM
SECTION A-A

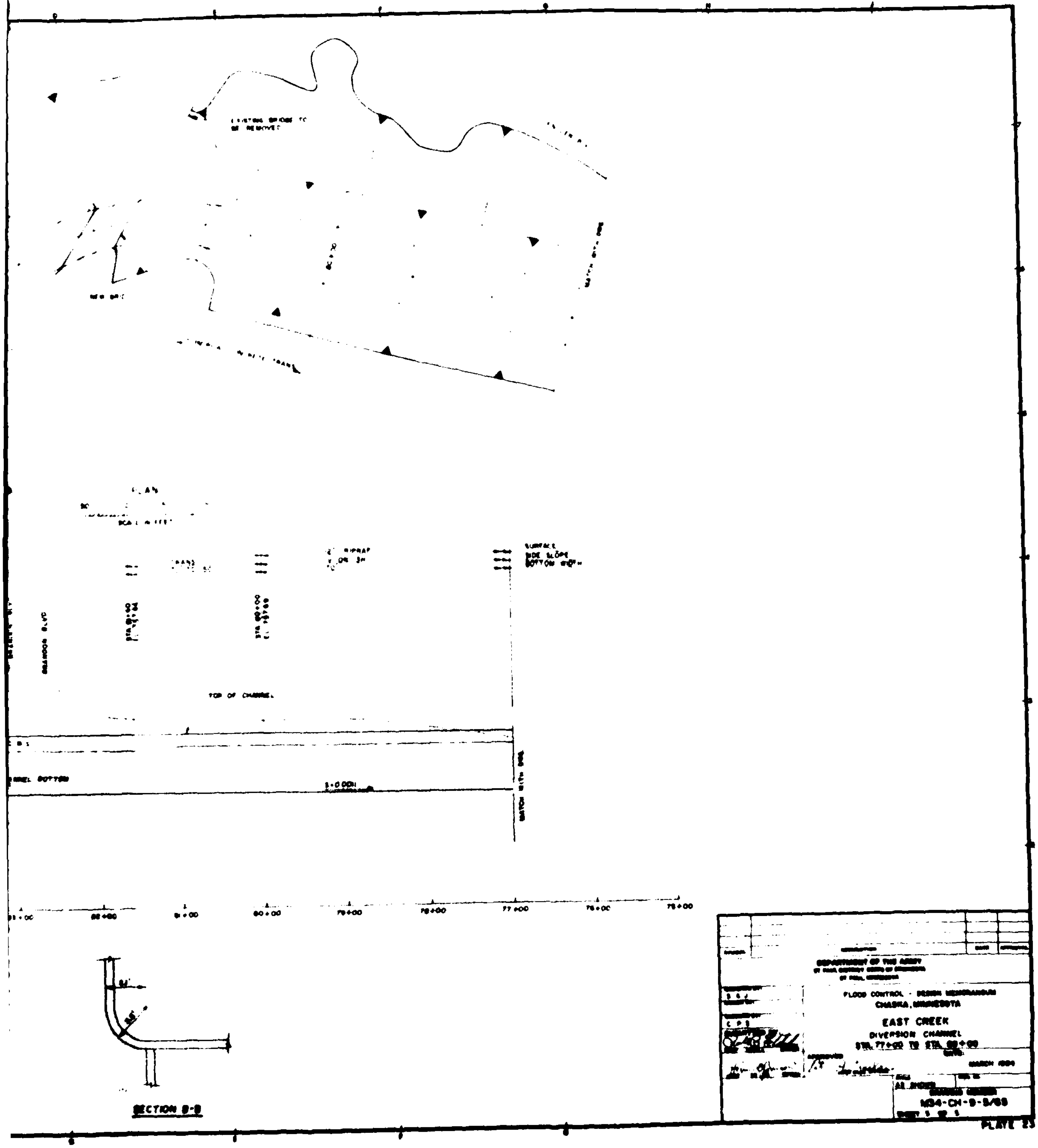
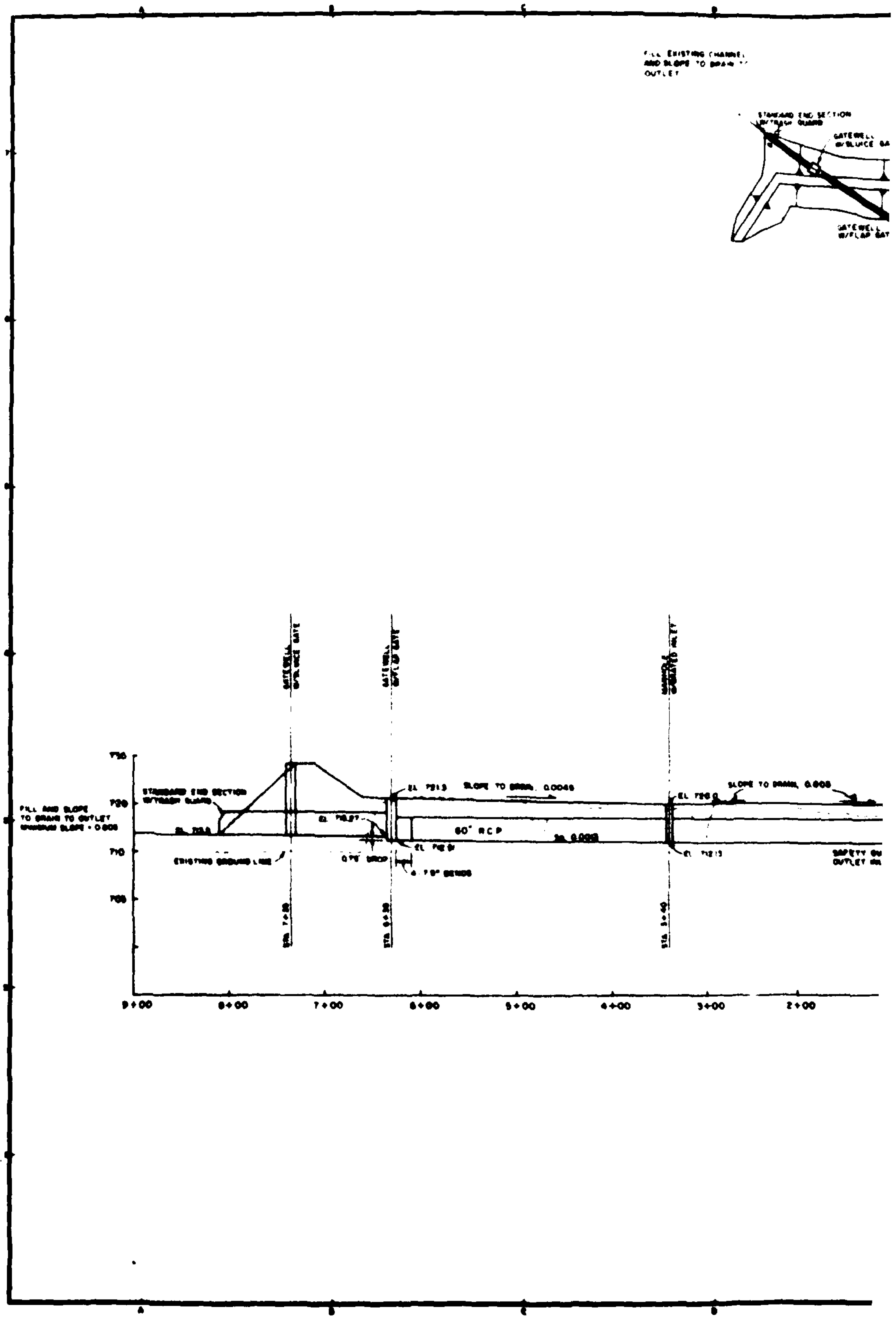
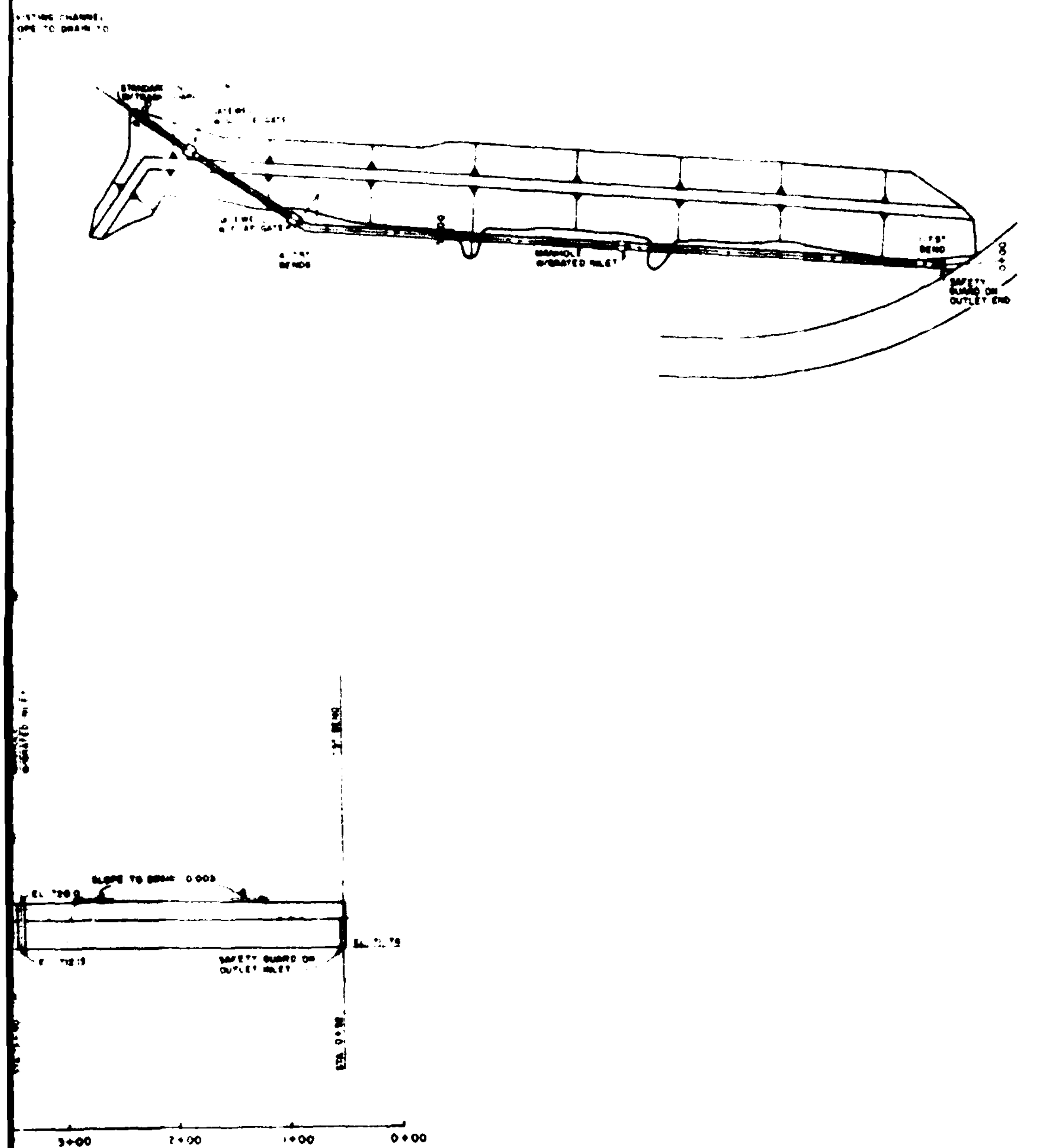

EXISTING BRIDGE TO BE REMOVED
PLAN
SURFACE
SIDE SLOPE
BOTTOM WIDTH
TOP OF CHANNEL
MATCH WITH DWG.
82+00
81+00
80+00
79+00
78+00
77+00
76+00
75+00
SECTION B-B
FLOOD CONTROL - DESIGN MEMORANDUM
CHASKA, MINNESOTA
EAST CREEK
DIVERSION CHANNEL
AS SHOWN

PLATE 23



STANDARD END SECTION
GATEWELL
SLOPE TO DRAIN, 0.0046
SLOPE TO DRAIN, 0.008
60" RCP
EXISTING GROUND LINE
FILL AND SLOPE
TO DRAIN TO OUTLET
720
710
9+00
8+00
7+00
6+00
5+00
4+00
3+00
2+00



DEPARTMENT OF THE ARMY

FLOOD CONTROL

DESIGN MEMORANDUM

CHASKA, MINNESOTA

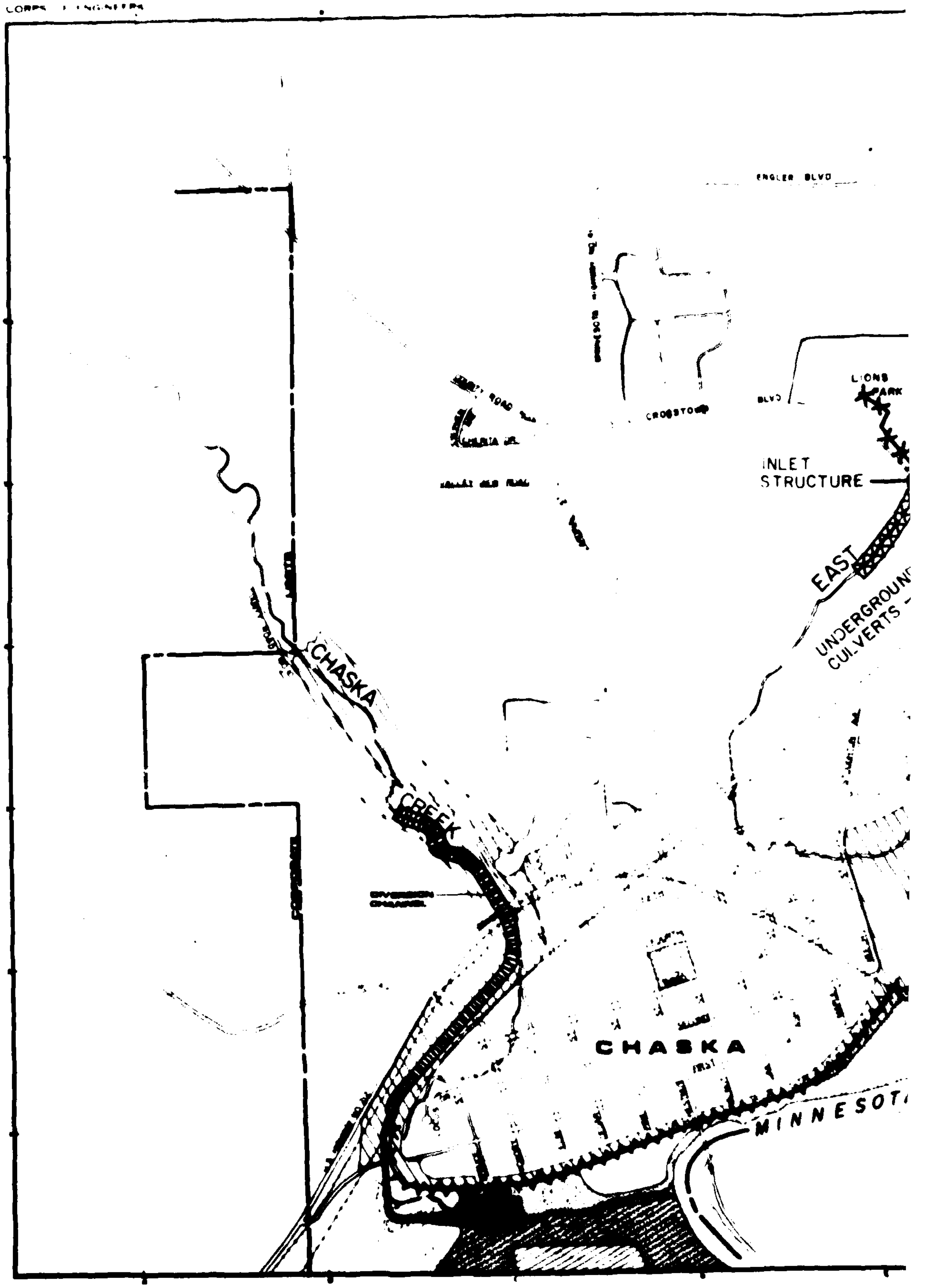
OUTLET A

PLAN & PROFILE

M34-CH-9-5/66

PLATE 24

CORPS OF ENGINEERS



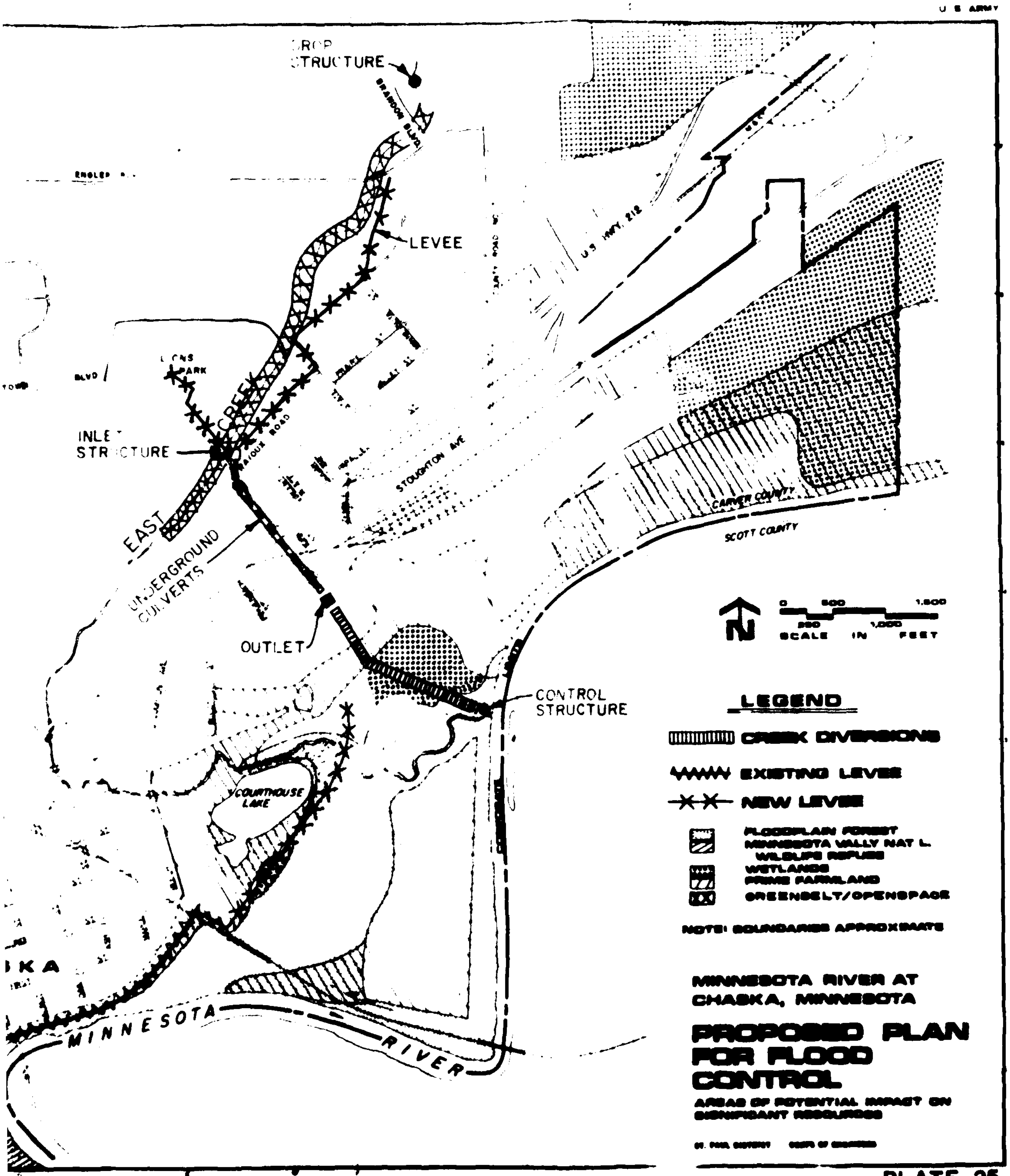
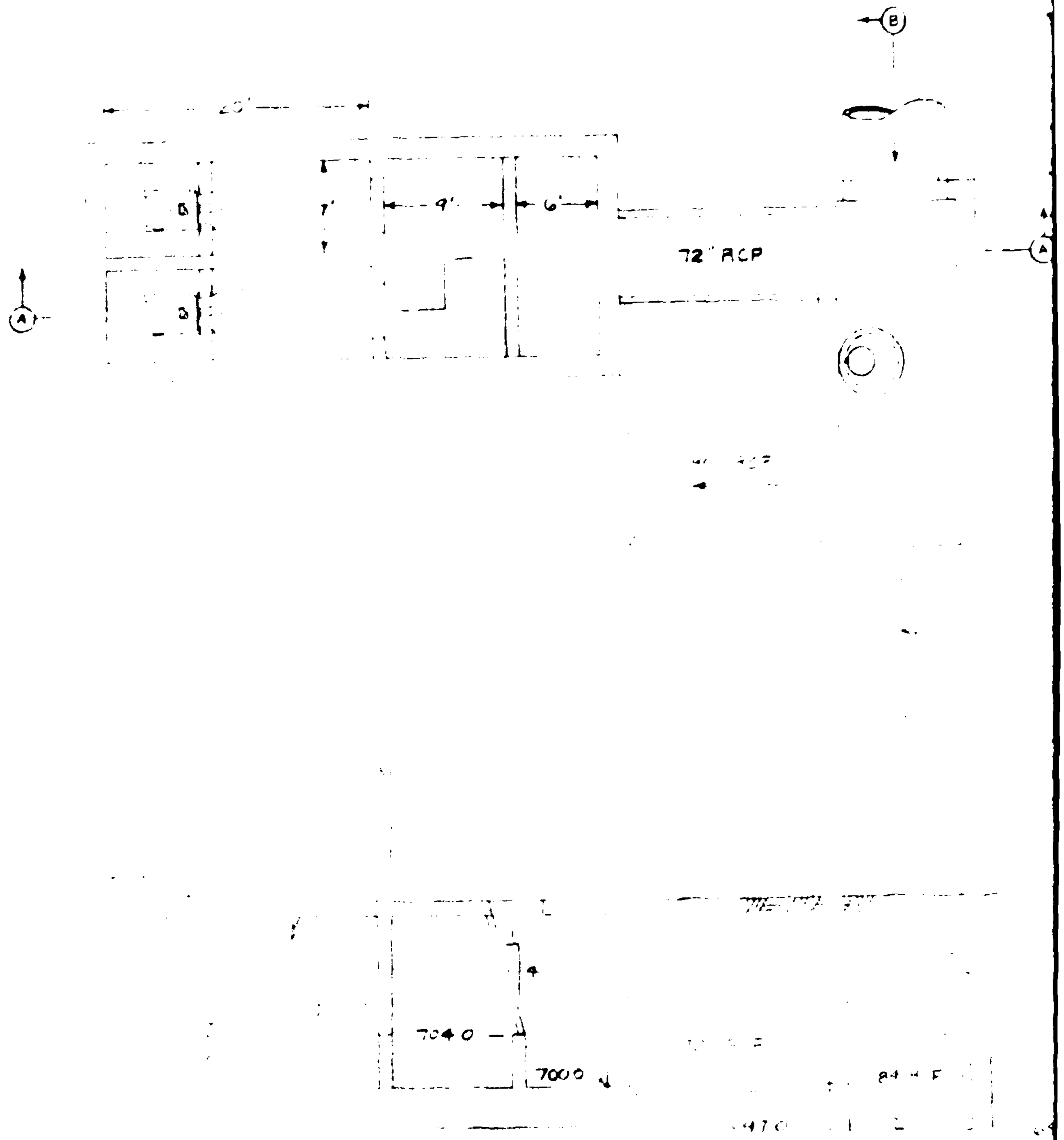
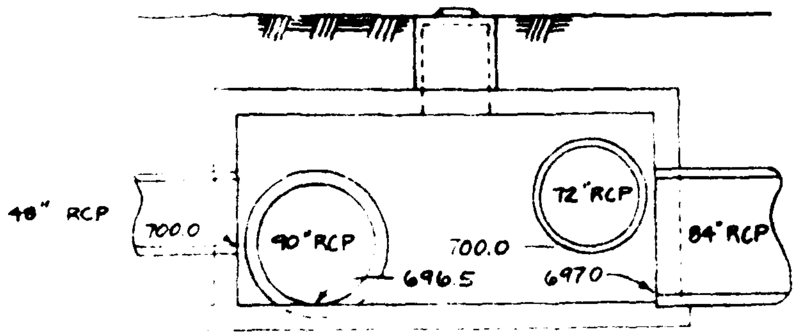

U S ARMY
STRUCTURE
LEVEE
U S HWY 212
STOUGHTON AVE
INLET STRUCTURE
EAST CREEK
UNDERGROUND CULVERTS
OUTLET
CONTROL STRUCTURE
COURTHOUSE LAKE
CARVER COUNTY
SCOTT COUNTY
MINNESOTA RIVER
0 500 1,500
250 1,000
SCALE IN FEET
LEGEND
CREEK DIVERSIONS
EXISTING LEVEE
NEW LEVEE
FLOODPLAIN FOREST
MINNESOTA VALLEY NAT L. WILDLIFE REFUGE
WETLANDS
PRIME FARMLAND
GREENBELT/OPENSPACE
NOTE: BOUNDARIES APPROXIMATE
MINNESOTA RIVER AT CHASKA, MINNESOTA
PROPOSED PLAN FOR FLOOD CONTROL
AREAS OF POTENTIAL IMPACT ON SIGNIFICANT RESOURCES
ST. PAUL DISTRICT CORPS OF ENGINEERS

PLATE 25



SECTION



SECTION B-B

CHASKA, MINN.

PUMPING STATION SCHEMATIC

PLATE 26

Table 2
Comparative Impacts of Alternati[illegible]
Chaska Flood Control Project Wi[illegible]
Alternative East Creek Diversion [illegible]

Alternatives/ Significant Resources	Floodplain Forest	East Creek Riparian and Aquatic Ecosystem	Floodplain Wetland/ Old Field Complex	Prime Farmland	Water Quality	Recreation Resources	Aesthetic Va[illegible]
Project area without condition (no action)	No impact.	No impact.	No impact.	Anticipated continued development of farmlands in urban areas.	No impact.	Lions Park, East Creek Trail, Courthouse Lake Trail, Open-space East Creek lands.	No impact on [illegible] creek and Min[illegible] River floodp[illegible] values.
Project with previously proposed design	About 17 acres removed for project structures.	Less than 1 acre riparian and aquatic habitat combined would be removed for project structures.	No impact	About 14 acres would be lost.	Increase in turbidity and sediment load of receiving waters of West Creek, East Creek, and Minnesota River during construction and high water events.	Development of Courthouse Lake Trail compatible with Minnesota River Valley Trail system. Minor impact on East Creek Trail and open-space lands.	Aesthetic valu[illegible] natural Chaska [illegible] and Minnesota [illegible] floodplain red[illegible] project featur[illegible] Planting on pr[illegible] lands should r[illegible] some aestheti[illegible]
Project with presently proposed design.	About 14 acres removed for project structures.	About 3 acres riparian and 2 acres aquatic habitat removed for project structures. Planting on project lands should reduce some impacts.	About 5 acres removed for project structures.	About 9 acres would be lost.	Same as above except more impact on East Creek during construction.	Same Courthouse Lake Trail development. Minor impacts on Lions Park. Disruption of East Creek Trail. Major impact on open-space lands by concrete channel above Engler Boulevard.	Aesthetic val[illegible] natural Chaska [illegible] East Creek Cha[illegible] and Minnesota [illegible] floodplain red[illegible] project featur[illegible] Planting on pr[illegible] lands should r[illegible] some aestheti[illegible]

Table [illegible]
Comparative Impacts of Alternatives
Chaska Flood Control Project With
Alternative East Creek Diversion Designs

Recreation Resources	Aesthetic Values	Cultural Resources	Fiscal Soundness	Neighborhood Stability	Transportation	Community Co[illegible]
Park, East Creek Courthouse Lake Open space East lands	No impact on natural Creek and Minnesota River floodplain values	No impact.	No impact.	No impact.	No impact.	No impact.
[illegible]pment of Courthouse trail compatible with [illegible]ota River Valley system. Minor impact [illegible]t Creek Trail and [illegible]pace lands.	Aesthetic values of natural Chaska Channel and Minnesota River floodplain reduced by project features. Planting on project lands should reduce some aesthetic impacts.	No known impacts to cultural resources. Continuation of survey effort will locate & assess previously unrecorded sites on the Minnesota River flood plain.	Project costs will impose potential economic strain on community or on groups within community.	5 residences & 2 businesses permanently relocated. 12 mobile homes relocated for 9-18 months. Possible changes in neighborhood composition in Old Chaska.	Disruption of County Hwy 17 (3 mos.), Riverview Rd (9-18 mos.), & Hickory St. (3 mos.), plus increased traffic volume and parking demand near construction sites.	Possible disruption due to perceived inequities in cost-bearing and residual flood risks.
[illegible]ourthouse Lake Tra[illegible] [illegible]pment. Minor impacts [illegible]ns Park. Disruption [illegible]st Creek Trail. Minor [illegible] on open-space lands [illegible]crete channel above [illegible]r Boulevard.	Aesthetic values of natural Chaska and East Creek Channels and Minnesota River floodplain reduced by project features. Planting on project lands should reduce some aesthetic impacts.	No known impacts to cultural resources. Detailed surveys will be conducted to locate and assess previously-unrecorded sites.	Same as above.	Current [illegible] [illegible] 9 residences will be permanently relocated by Minnesota River levee and Chaska Creek features. No permanent residential relocations necessary for East Creek features except for one [illegible] mobile home.	Disruption of County Hwy 17 (3 mos.), Hwy 212 at Chaska Creek (3 wks.), Walnut St. (3 mos.), [illegible] at 212, Commerce Blvd., Stoughton Ave., and Chaska Creek (3 mos.), Commerce Blvd. (4 mos.), Stoughton Ave. (3 wks.), Engler Blvd. (2 mos.), & Hwy 212 at Commerce (4 wks.). Same construction impacts as above.	Same as above.

Water Quality

4.15 Potential project effects on the water quality of [illegible] Lake and West Creek are [illegible] discussed in the previous [illegible] Creek Reservoir Design Memorandum [illegible] pages [illegible] to [illegible] and [illegible] to [illegible] of the [illegible] for discussions of existing water quality and potential effects of the project, including the previous [illegible] design. The temporary increase in sedimentation in the creek as a result of construction activities and long-term project operation remain the primary areas of concern with regard to potential water quality impacts.

[illegible]

4.16 [illegible] occurring in the study area could be affected by the proposed project. The first is [illegible] Lands. This [illegible] The second is the [illegible] forest bordering the [illegible] River. These woodlands provide a corridor for the [illegible] Valley [illegible] Trail. The third is [illegible] Park at West Creek, [illegible] natural [illegible]

[illegible]

4.17 [illegible]

(1) [illegible]

(2) Reduce the hazard and risk of flood loss.

(3) Minimize the impact of floods on human safety, health and welfare.

(4) Restore and preserve the natural and beneficial floodplain values.

(5) Avoid [illegible] in the floodplain [illegible], alleys, [illegible] and [illegible] facilitating additional floodplain development.

5.42 Approximately 13.5 [illegible] in the [illegible] (west of County [illegible], north of [illegible]) would be [illegible] with the [illegible]. [illegible]

[illegible]

5.43 The [illegible] of the [illegible] project would lead to the loss and [illegible]. [illegible] (July 1973) [illegible] (August [illegible]) [illegible].

[illegible]

PRELIMINARY SECTION 404(b)(1) EVALUATION
FOR FILL ACTIVITY ASSOCIATED WITH THE
EAST CREEK FLOOD DIVERSION FEATURE OF
THE FLOOD CONTROL PROJECT ON THE
MINNESOTA RIVER AT CHASKA, MINNESOTA

I. PROJECT DESCRIPTION

a. Location

The proposed fill activity would take place on East Creek, a tributary stream of the Minnesota River, at Chaska, Minnesota.

b. General Description

The proposed action would include (1) construction of a 1500-foot-long, 50-foot-wide, concrete, rectangular channel on East Creek from Engler Boulevard through part of the Brandondale mobile home park, (2) construction of a 4600-foot levee south of East Creek starting at Engler Boulevard and crossing East Creek at Crosstown Boulevard to border Lions Park, (3) construction of an inlet structure on East Creek where it meets Crosstown Boulevard to divert flood flows to an underground culvert, (4) construction of an 1800-foot long outlet channel south of the terminus of the underground culvert below Bierline Road that would intersect with the mouth of East Creek on the Minnesota River. The diversion feature is similar to a previously-evaluated East Creek feature (see the final Section 404(b)(1) evaluation in the August 1982 final supplement to the final EIS on the entire Chaska project) except that the proposed point of diversion is about 4,000 feet downstream from the previous site.

c. Authority and Purpose

The proposed plan for flood control in Chaska, Minnesota, was authorized by Congress in the 1976 Water Resources Development Act, Public Law 94-587, House Document 94-644.

d. General Description of Dredged or Fill Material

(1) General Characteristics of Material - Soil material would be impervious glacial till. Riprap would be 12 inches in diameter or length. Concrete aggregate would be natural aggregate or crushed rock. Bedding material would be clean limestone quarry material.

(2) Quantity of Material - Approximately 12,000 cubic yards of riprap, 348,000 cubic yards of levee fill, 19,000 cubic yards of bedding, and 55,000 cubic yards of concrete would be used for the East Creek feature.

EXHIBIT 1

(3) Source of Material - Much of the berm and embankment material required for the project would be generated by excavation of the flood storage area. The remainder of construction materials required could be acquired from commercial sources in the area.

Riprap and bedding of adequate quality could be obtained from limestone quarries in the Prairie du Chien formation on the south side of the Minnesota River Valley within 10 miles of Chaska.

Concrete aggregate of adequate quality could be obtained from continuously-operating sources of natural aggregate and crushed rock in the Minneapolis-St. Paul metropolitan area, 25 to 50 miles from the project site. Sources located within 10 miles of Chaska exist, but these produce concrete aggregate only intermittently. Although these closer sources have not been tested or used for Corps of Engineer projects, information obtained from the Minnesota Department of Highways indicates their material would be adequate as a concrete aggregate.

Levee fill would be obtained from the diversion and bypass channel excavations. A plentiful supply of this material is available from the surrounding uplands if sufficient quantities are not obtainable from channel excavations.

e. Description of Proposed Discharge Sites

(1) Location - Plate 1 of the phase II general design memorandum for this project shows the locations of East Creek features in Chaska.

(2) Size - The proposed concrete rectangular channel on East Creek is about 1.7 acres. The levee is about 5.3 acres. The inlet structure is about .10 acre. The outlet channel is about 12 acres.

(3) Type of Sites - The fill activities would take place in stream, river floodplain forest, and river floodplain wetlands in unconfined sites.

(4) Types of Habitat - Stream-bottom aquatic habitat, stream-side riparian habitat, floodplain forest (bottomland hardwoods), and palustrine, seasonally-flooded, floodplain wetland.

(5) Timing and Duration of Discharge - If construction funding is appropriated, construction would begin in 1986 and would be completed by 1989.

f. Description of Disposal Method
The fill material would be placed by trucks, front-end loaders, tractors, concrete mixers, and other mechanical means.

II. FACTUAL DETERMINATIONS

a. Physical Substrate Determinations

(1) Substrate Elevation and Slope - East Creek near Engler Boulevard has an elevation of 758 feet msl and a channel slope gradient of 0.0011 feet per foot. The side slopes average 2 feet horizontal for every foot vertical. East Creek at Crosstown Boulevard is at 740 feet msl. The elevation of the substrate in the area of the outlet channel ranges from 709 to 700 msl. The slope gradient to the Minnesota River is about 0.0002 feet per foot.

(2) Sediment Type - The East Creek channel bottom consists of sand, silt, and occasional rocky reaches. The floodplain sediments are a combination of silt and clay.

(3) Fill Material Movement - Some movement of fine bedding (silt and clay) material could occur during construction. Construction would be avoided during periods of high discharge (spring runoff and heavy rainstorms) to minimize fill material movement. Riprapping with rocks or placing concrete in high-energy areas would be done shortly after the bedding material is placed to reduce the potential for movement. Riprap and concrete fill would not move unless dislodged by damage or extremely rare flood events.

b. Water Circulation, Fluctuation, and Salinity Determinations

(1) Water

(a) Salinity - Not applicable.
(b) Water Chemistry - The placement of clean fill material should not have any significant impacts on East Creek's water chemistry.
(c) Clarity - Some minor, short-term decreases in clarity in East Creek would be expected during the fill activities because of the presence of silts and clays in the borrow material. However, once the riprap or concrete is in place, there should be a slight improvement in water clarity because the erosion that presently occurs would be reduced.
(d) Color - The proposed fill activity should have no impact on water color.
(e) Odor - The proposed fill activity should have no impact on water odor.
(f) Taste - The proposed fill activity should have no appreciable impact on water taste.
(g) Dissolved Gas Levels - The proposed fill activity should have very minimal impact on dissolved gas levels.

Because aerobic sediments with only small amounts of organic material would be used as fill, no impact on dissolved oxygen levels is expected.

(h) Nutrients - The proposed fill activity should have no significant impact on nutrient levels in the water.

(i) Eutrophication - The proposed fill activities should have no impact on the level or rate of eutrophication of the water.

(2) Current Patterns and Circulation

(a) Current Patterns and Flow - The purpose of the proposed project is to change current patterns and flow conditions in East Creek to reduce flood damages for the city of Chaska. Current patterns and flow would be altered in 9,500 feet of stream channel by construction of the high-flow diversion channel, and restricting flows downstream of the diversion structure.

(b) Velocity - The velocity of water going through the low-flow culvert at Crosstown Boulevard would be significantly reduced below existing conditions during flood events because most of the floodwaters would be diverted away from the existing channel. If rare conditions warranted completely closing off the low-flow structure, velocity would be further reduced downstream. During very large flood events, water would be allowed to flow over the streambanks to take advantage of the natural retarding effect of surrounding parklands to further reduce flood flow velocities before reaching the diversion structure. The diverted flood flows in the outlet channel would approach 3 feet per second. Concrete block energy dissipators in the outlet channel would help reduce velocities.

(c) Stratification - The proposed fill activities would have no significant impact on stratification.

(d) Hydrologic Regime - The proposed activity would have no significant impact on the hydrologic regime.

(3) Normal Water Level Fluctuations - The levee built south of the creek upstream of the inlet structure would constrict sheet flood flows, thereby preventing structural damages to adjacent residences. Downstream of the inlet structure, water-level fluctuations during floods would be significantly reduced because most of the flood flows would be diverted away. Water-level fluctuations in the Minnesota River would not be significantly changed by diverting East Creek flood flows. Normal low flows in East Creek would not be affected.

(4) Salinity Gradient - Not applicable.

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Because aerobic sediments with only small amounts of organic material would be used as fill, no impact on dissolved oxygen levels is expected.

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(4) Salinity Gradient - Not applicable.

(5) Actions that Will Be Taken to Minimize Impacts - Retention of normal flows below the diversion structure would maintain the natural and aesthetic qualities of East Creek. The use of clean fill materials would help reduce water quality impacts. Placement of rock riprap and concrete shortly after placement of base materials would reduce movement of the base materials from the site (see also section III.h.).

c. Suspended Particulate/Turbidity Determinations

(1) Expected Changes in Suspended Particulates and Turbidity Levels in Vicinities of Fill Sites - Construction activities such as excavation and fill placement would elevate levels of turbidity and suspended particulates. Some of the bedding material would mix with stream water during placement. Some erosion may occur prior to stabilization with rock riprap or concrete. This erosion would also elevate both turbidity and suspended particulate levels, but the increases are expected to be relatively minor and short-term.

(2) Effects on Chemical and Physical Properties of Water Column - Because of the clean nature of the fill material, there should be a negligible effect on the chemical properties of the water column. However, there may be a slight decrease in light penetration as a result of the increases in turbidity and suspended solids.

(3) Effects on Biota - The biotic community of the East Creek aquatic ecosystem is not extensive in terms of either mass or species diversity mainly because of low average annual flows. In the 1500-foot reach where concrete channel would replace the existing natural channel, primary production, photosynthesis, suspension/filter feeders, and sight feeders would almost be completely eliminated. In other reaches of East Creek, effects on biota would be short term during construction activities, and normal biotic processes should return to normal after the channel becomes stabilized.

(4) Actions Taken to Minimize Impacts - See sections II b. (5) and III. h.

d. Contaminant Determinations

The term "contaminant" is defined by U.S. EPA Guidelines (40 CFR 230.3(e)) as "a chemical or biological substance in a form that can be incorporated into, onto, or be ingested by and that harms aquatic organisms, consumers of aquatic organisms, or users of the aquatic environment, and includes but is not limited to the substances on the 307(a)(1) list of toxic pollutants promulgated on January 31, 1978" (Federal Register, Vol. 43, 4109).

Quarrystone (limestone) used for bedding riprap is considered to be basically inert fill material. Earth-fill material to be used appears to meet exclusion criteria for testing the chemical-biological interactive effects outlined in 40 CFR 230.4(b)(2), and (3), and no further testing on this material will be conducted. Such material may be excluded from the aforementioned testing if any of the exclusiton criteria are met, as defined in 40 CFR 230.41(b)(i), (ii), or (iii). Briefly stated, the applicable exclusion criteria are (i) that the fill material must be composed predominantly of sand, gravel, or other naturally occuring sedimentary material with particle sizes larger than silt, usually found in glacial deposits and (iii) that the material proposed for discharge must be primarily the same as at the discharge site. This final criterion requires that the fill material be sufficently removed from sources of pollution to provide reasonable assurances that the material is not polluted from such sources, and that adequate conditions are provided on the placement method to provide reasonable assurance that discharged material would not be moved by currents or otherwise in a manner that is damaging to the environment outside the disposal area. Earth fill to be used on this project would predominantly consist of natural glacial material that is unpolluted, which would be obtained from a borrow area adjacent to or near the fill site. Composition of cement to be used to construct the box culverts and sills would be primarily calcium silicates and water and would not contribute toward significant contamination of water quality, except for some minor temporary turbidity.

e. Aquatic Ecosystem and Organism Determination

(1) Effects on Plankton - Increases in turbidity and suspended solids near the fill activities would have a localized suppressing effect on phytoplankton and zooplankton productivity. The plankton populations should recover quickly once the fill and other construction activities have ceased.

(2) Effects on Benthos - Much of the fill activity would occur above the normal low flow and would have little effect on the benthic populations in the area. Benthic organisms could be covered by sediments during the construction period. Benthic habitat would be destroyed by the 1500-foot concrete rectangular channel that would be located above Engler Boulevard, and some would be partially destroyed by construction of the inlet wier at Crosstown Boulevard.

(3) Effects on Nekton - See Effects on Plankton, II. e. (1).

(4) Effects on Aquatic Food Web - As stated above, the biotic community in East Creek is not extensive. In the reaches of East

Creek that would be changed from natural to concrete channel, the aquatic food web originally existing in those reaches would be substantially reduced in terms of productivity, abundance, and species diversity.

(5) Effects on Special Aquatic Sites

(a) Wetlands - The grass-lined outlet channel would fill 3 acres of Minnesota River floodplain wetland. Although the channel would provide limited habitat for some species, it would not fully replace the values of this important wildlife habitat.

(b) Riffle and Pool Complexes - These complexes would be eliminated in the East Creek reach above Engler Boulevard by construction of the concrete rectangular channel. Downstream of the Crosstown Boulevard diversion structure, the nature of pool and riffle complexes would be modified during high water events on East Creek because of the reduced velocity and amount of flow.

(6) Threatened and Endangered Species - The proposed activity should have no impact on threatened or endangered species.

(7) Other Wildlife - In addition to impacts on aquatic biota and the floodplain wetland wildlife habitat described above in sections II. c. (3) and e. (1-5), East Creek riparian wildlife would be adversely affected by removal of riparian vegetation for construction of the concrete channel, inlet structure, and some portions of the levee. In addition, construction of the outlet channel of the diversion near the mouth of East Creek would eliminate 3 acres of bottomland hardwoods important to floodplain forest species such as white-tailed deer, small mammals, and birds.

(8) Actions to Minimize Impacts - See section III. h.

f. Proposed Disposal Site Determinations

(1) Mixing Zone Determination - Because the fill material is clean, the mixing zone for suspended contaminants would be very minimal. A turbidity and suspended particulate plume would be generated by the fill activity, but the mixing zone should be small.

(2) Determination of Compliance with Applicable Water Quality Standards - East Creek is rated by the State of Minnesota as a Class 2B stream for cool and warm water fisheries and recreation. Fill activities would comply with State water quality standards, except during construction when turbidity levels could exceed acceptable limits. This effect would be temporary and should not have any long-term adverse effects on the environment.

(3) Potential Effects on Human-Use Characteristics

(a) Municipal and Private Water Supply - The proposed action would not affect water supplies.
(b) Recreational and Commercial Fisheries - Because fisheries in East Creek are very limited and supply almost negligible consumptive use, the proposed action would have little impact on this use.
(c) Water-Related Recreation - East Creek is in urban residential and parkland areas of Chaska and is used as a recreational resource by local citizens. Construction of the concrete channel and the concrete inlet wier would substantially change the nature of recreational uses of East Creek because of the loss or modification of the natural channel. Recreational uses compatible with a concrete channel bottom would be available after construction.
(d) Aesthetics - Although plantings of native trees and other vegetation are planned for project areas, the project structures are less aesthetically pleasing than the natural stream channel, riparian, wetland, and bottomland hardwood areas that they would replace.
(e) Parks and Similar Preserves - The East Creek channel structures and some of the levee would be on greenbelt/open-space-designated lands of Chaska that were bought with Federal Land and Water Conservation Act funds for the purpose of maintaining these areas as natural or open space and providing recreational use compatible with those designations. Coordination between the city of Chaska and the U.S. Department of Interior has been initiated to determine if the project constitutes a significant conflict with the open-space designation.

g. Determination of Cumulative Effects on the Aquatic Ecosystem
Implementation of the proposed fill activity should cause no significant cumulative impacts on the aquatic ecosystem. Effects would be immediate where they are significant.

h. Determination of Secondary Effects on the Aquatic Ecosystem
There should be no secondary effects of the proposed fill activities.

III. FINDINGS OF COMPLIANCE OR NON-COMPLIANCE WITH THE RESTRICTIONS ON DISCHARGE

a. Adaptation of the Section 404(b)(1) Guidelines to this Evaluation
The proposed fill activity would be in compliance with the Section 404(b)(1) guidelines of the Clean Water Act. (See section III. i., below.)

b. Evaluation of Availability of Practicable Alternatives to the Proposed Discharge Site That Would Have Less Adverse Impact on the Aquatic Ecosystem
The previously-proposed East Creek diversion design that would have taken a different alignment to the Minnesota River would have less impact on the aquatic ecosystem of East Creek because in-channel structures would not be nearly as extensive as the presently-proposed design. The East Creek diversion design change is currently proposed for the following reasons:

(1) It reduces the construction cost.
(2) It provides flood protection for a greater portion of the urban area by reducing the size of the residual floodplain.
(3) It substantially reduces the number of residential relocations.

See also the Alternatives section in draft supplement II to the FEIS and pages 8 to 12 of the phase II general design memorandum for more detailed evaluations of the alternatives.

c., d, and e. Compliance with Applicable State Water Quality Standards, Compliance with Applicable Toxic Effluent Standard or Prohibition Under Section 307 of the Clean Water Act, and Compliance with Endangered Species Act of 1973
The presently-proposed fill activity would be in compliance with the State water quality standards, except for temporary turbidity increases during construction, with Section 307 of the Clean Water Act, and with the Endangered Species Act of 1973, as amended.

f. Compliance with Specified Protection Measures for Marine Sanctuaries Designated by the Marine Protection, Research, and Sanctuaries Act of 1972
Not applicable.

g. Evaluation of Extent of Degradation of the Waters of the United States
The presently-proposed fill activity should not have a significant impact on human health and welfare. Plankton, nekton, benthic organisms, fish, and some bank-dwelling wildlife would be disrupted or eliminated in certain areas because of the following factors: burial of existing aquatic habitat, change in current circulation patterns and water velocity, change of physical substrate, and

increased turbidity and suspended particulates during construction. Project structures would substantially reduce habitat values for wildlife in parts of the East Creek riparian ecosystem and in the Minnesota River floodplain forest and wetland/old field habitats. In those reaches of the existing East Creek natural channel that would be changed to concrete channel, there would be a significant adverse effect on aquatic ecosystem diversity, productivity, stability, and aquatic life dependent on the aquatic ecosystem. It is recognized, however, that the biotic communities in these reaches are not currently extensive in terms of populations, productivity, or species diversity.

In the reaches of the East Creek natural channel that would be changed to concrete channel, there would be significant adverse effects on aesthetics and existing recreational uses. The outlet channel in the Minnesota River floodplain would have a significant adverse effect on the aesthetic values of this area.

h. Appropriate and Practicable Steps Taken to Minimize Potential Adverse Impacts of the Discharge on the Aquatic Ecosystem

(1) Only clean fill material, such as rocks, concrete, and bedding material, would be used to reduce the possibility of contaminant introductions.

(2) Mechanical means would be used to place the fill material and to place concrete or riprap shortly after foundation preparation to reduce the effects on turbidity and suspended particulate levels and movement of material from the site.

(3) A 48-inch reinforced concrete pipe would be installed under Crosstown Boulevard to convey normal low flows through the natural East Creek channel downstream.

(4) During construction, the contractor would follow specific guidelines to minimize construction-related impacts. The contractor would comply with Federal, State, and local laws and regulations concerning water pollution. The contractor would submit a plan for controlling erosion and waste disposal. Temporary erosion and sediment control measures would be provided as long as they are needed or until permanent facilities are completed. Stream crossings by equipment would be limited to control turbidity. Temporary culverts or bridges would be removed upon project completion. During diversion operations, the contractor would conduct operations so as to minimize turbidity increases. Disposal of wastes would be conducted properly, and measures to prevent spillages into water bodies would be undertaken.

i. Compliance of the Proposed Discharge Site with the Guidelines for the Discharge of Dredged or Fill Material

On the basis on this evaluation, the proposed disposal sites for the discharge of fill material are specified as complying with the requirements of these guidelines with the inclusion of appropriate and practical conditions to minimize pollution or adverse effects to the affected aquatic ecosystem, as specified in section III. h. above.

FINDING OF COMPLIANCE FOR FILL ACTIVITY ASSOCIATED WITH THE EAST CREEK FLOOD DIVERSION FEATURE OF THE FLOOD CONTROL PROJECT ON THE MINNESOTA RIVER AT CHASKA, MINNESOTA

1. No significant adaptations of the guidelines were made for this evaluation.

2. The previously-proposed East Creek diversion design that would have taken a different alignment to the Minnesota River would have less impact on the aquatic ecosystem of East Creek. However, the East Creek diversion design change is currently proposed because of reduced construction costs, greater flood protection, and reduced numbers of necessary residential relocations.

3. The placement of fill material for the diversion feature would not violate any applicable State water quality standards with the exception of the turbidity standard. Clean fill from bank excavations or local commercial sources of known uncontaminated material would be used. Construction would occur primarily during periods of low water or in the dry. The disposal operation would not violate the Toxic Effluent Standards of Section 307 of the Clean Water Act.

4. Fill placement would not harm any endangered or threatened species, or its critical habitat.

5. The proposed placement of fill material for the East Creek diversion feature would not result in significant adverse effects on human health and welfare, including municipal and private water supplies, recreational fishing, plankton, fish, shellfish, wildlife, or special aquatic sites. Unacceptable adverse effects on aquatic ecosystem diversity and productivity, and on recreational, aesthetic, and economic values would not occur.

6. Appropriate steps to minimize potential adverse effects of the fill placement on aquatic systems include use of clean fill materials, construction primarily during low-water periods, and the adaption of construction procedures to minimize soil erosion and water pollution, including sediment traps and other measures, as well as "good housekeeping" practices around construction sites.

7. On the basis of the guidelines, the proposed fill activity is specified as complying with the 404 (b) (1) guidelines, with the inclusion of appropriate and practical conditions to minimize pollution or adverse effects to the aquatic ecosystem.

Date

Edward G. Rapp
Colonel, Corps of Engineers
District Engineer

United States Department of the Interior

IN REPLY REFER TO

FISH AND WILDLIFE SERVICE
St Paul Field Office, Ecological Services
570 Nalpak Building
333 Sibley Street
St. Paul, Minnesota 55101

February 13, 1984

Mr. Louis Kowalski
Chief, Planning Division
U.S. Army Corps of Engineers
1135 U.S. Post Office and Custom House
St. Paul, Minnesota 55101

Dear Mr. Kowalski:

This replies to your letter of February 6, 1984 concerning the possible impacts on federally endangered or threatened species from the revised Chaska Flood Control project at Chaska, Carver County, Minnesota.

Presently, there are no federally listed threatened or endangered species that occur within Carver County. However, the endangered Higgin's eye pearly mussel (Lampsilis higginsi) is listed as occurring in the lower Minnesota River. Limited information exists on the distribution of this species in the Minnesota River and malacologists believe it to be extirpated from this river system. Therefore, this construction project should have "no effect" on listed species or their critical habitat. This precludes the need for further action on this project as required under Section 7 of the Endangered Species Act of 1973, as amended. However, if new information indicates endangered species may be affected, consultation with this office should be reinitiated.

These comments have been prepared under the authority of and in accordance with provisions of the Endangered Species Act of 1973, as amended. Comments on the revised project with respect to the Fish and Wildlife Coordination Act will be provided in a supplemental report to our final Fish and Wildlife Coordination Act Report.

Sincerely,

Robert F. Welford

Robert F. Welford
Field Office Supervisor

EXHIBIT 2

United States Department of the Interior

FISH AND WILDLIFE SERVICE

St. Paul Field Office, Ecological Services
570 Nalpak Building
333 Sibley Street
St. Paul, Minnesota 55101

IN REPLY REFER TO:

March 1, 1984

Colonel Edward G. Rapp
District Engineer, St. Paul District
U.S. Army Corps of Engineers
1135 U.S. Post Office and Custom House
St. Paul, Minnesota 55101

Dear Colonel Rapp:

The U.S. Fish and Wildlife Service has completed the attached Draft Supplemental Report to the Final Fish and Wildlife Coordination Act Report for the Chaska Flood Control Project in Chaska, Carver County, Minnesota. The draft supplemental report recommends measures to avoid and minimize adverse impacts to selected habitats, recommends measures to improve project lands for wildlife purposes, and quantifies unavoidable habitat losses to be compensated for the revised flood control project.

This draft report is being submitted for review to enable the Corps' comments to be incorporated into the final supplemental report for the revised Chaska Flood Control Project. We look forward to receiving your comments on this report and our continued coordiation on the Chaska project.

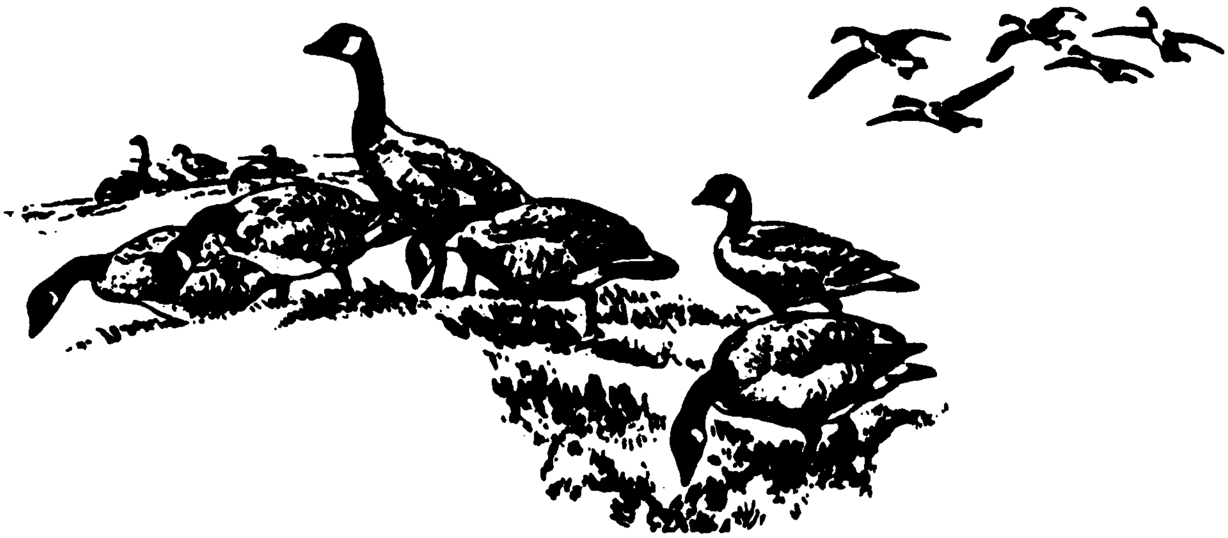
Sincerely,

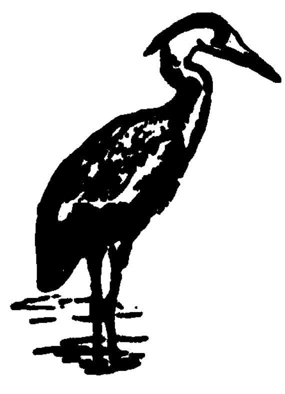
James L. Smith

James L. Smith
Acting Field Supervisor

cc: MDNR, St. Paul, MN
MPCA, Roseville, MN
EPA, Chicago, IL
City of Chaska, MN

DRAFT SUPPLEMENTAL REPORT TO FINAL FISH & WILDLIFE COORDINATION ACT REPORT





CHASKA FLOOD CONTROL PROJECT

MARCH 1984

EIS-49

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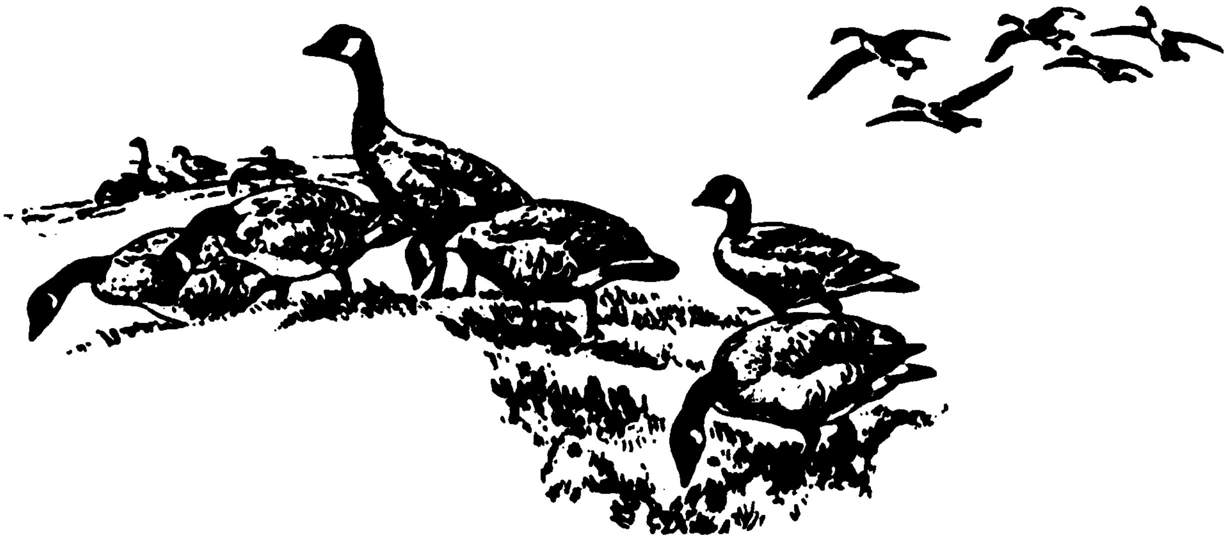
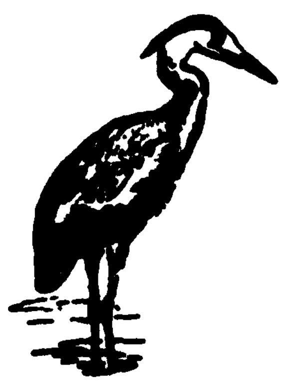


U.S. FISH & WILDLIFE SERVICE

CHASKA FLOOD CONTROL PROJECT



MARCH 1984

EIS-49

CHASKA FLOOD CONTROL PROJECT

CHASKA, CARVER COUNTY

MINNESOTA

Draft Supplement to

Final Fish and Wildlife Coordination Act Report

Submitted to the

U.S. Army Corps of Engineers

St. Paul District

St. Paul, Minnesota

United States Fish and Wildlife Service

Division of Ecological Services

St. Paul Field Office

March 1984

EIS-51

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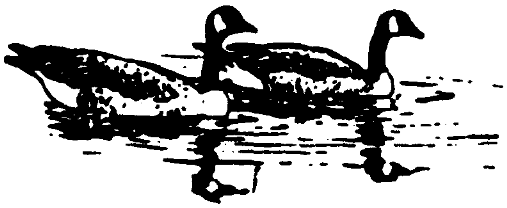
*Refers to numbers at top of page, not to the EIS numbers.

SECTION I

Introduction



I. Introduction

On December 23, 1981, the U.S. Fish and Wildlife Service submitted a draft Fish and Wildlife Coordination Act (FWCA) report to the St. Paul District Corps of Engineers for the Chaska Flood Control Project in Chaska, Carver County, Minnesota (USFWS 1981b). This report, adopted by the Service on August 27, 1982 as the final FWCA report, was based on the findings of a habitat evaluation conducted by a tri-agency team of biologists representing the Minnesota Department of Natural Resources, U.S. Army Corps of Engineers, and U.S. Fish and Wildlife Service. The tri-agency team's analysis was conducted in accordance with the Service's Habitat Evaluation Procedures (HEP) and Mitigation Policy. The FWCA report recommended measures to improve project lands for wildlife purposes, quantified project impacts to fish and wildlife resources, and recommended three alternative compensation proposals to replace unavoidable habitat losses. One of these proposals (Compensation Proposal A) involving construction of a water control structure on Chaska Lake and a moist soil management unit was subsequently selected by the Corps of Engineers for implementation as part of the overall Chaska Flood Control Project (Corps of Engineers, 1982).

Recently, the St. Paul District has proposed a new alignment for the

East Creek diversion channel. The District has requested the Service to prepare a draft supplement to the final FWCA report. Specifically, this report will: (1) evaluate the location and design of the revised East Creek diversion channel to determine its effects on fish and wildlife resources in the project area; (2) recommend measures to avoid and minimize adverse impacts to fish and wildlife habitats; (3) recommend measures to improve project lands for fish and wildlife purposes; and (4) recommend additional mitigation measures if adverse impacts to fish and wildlife resources cannot be fully mitigated through design modification or implementation of Compensation Proposal A. The format of this supplemental report will follow that of the final FWCA report.

Description of Chaska Flood Control Project

There are two components to the flooding problems at Chaska: (1) main stem flooding from the Minnesota River, and (2) flooding from tributaries (East and Chaska Creeks) to the Minnesota River. The selected solution to the first problem is the extension and renovation of the existing emergency levee. To reduce flood damages associated with East and Chaska Creeks, two diversion channels are proposed. The proposed Chaska Creek diversion channel will generally be a concrete and riprap structure which will divert all existing flows through the channel.

The original design and alignment of the East Creek diversion channel would divert flood flows around the east side of the City of Chaska; normal flows would continue in the existing East Creek channel. The diversion channel would consist of approximately 3,500 feet of trapezoidal, grass-lined earth channel having 1 on 3 side slopes and a 30-foot bottom width and approximately 1,600 feet of 14-foot diameter soft earth tunnel. The design included four drop structures, a parabolic drop spillway, and a preformed scour hole.

The revised East Creek diversion channel is located to the west of the original alignment and would divert flood flows under Crosstown Boulevard, on the east side of the City, and directly to the Minnesota River (Fig. 1). Under normal flow conditions, water would continue to flow down the existing East Creek channel.

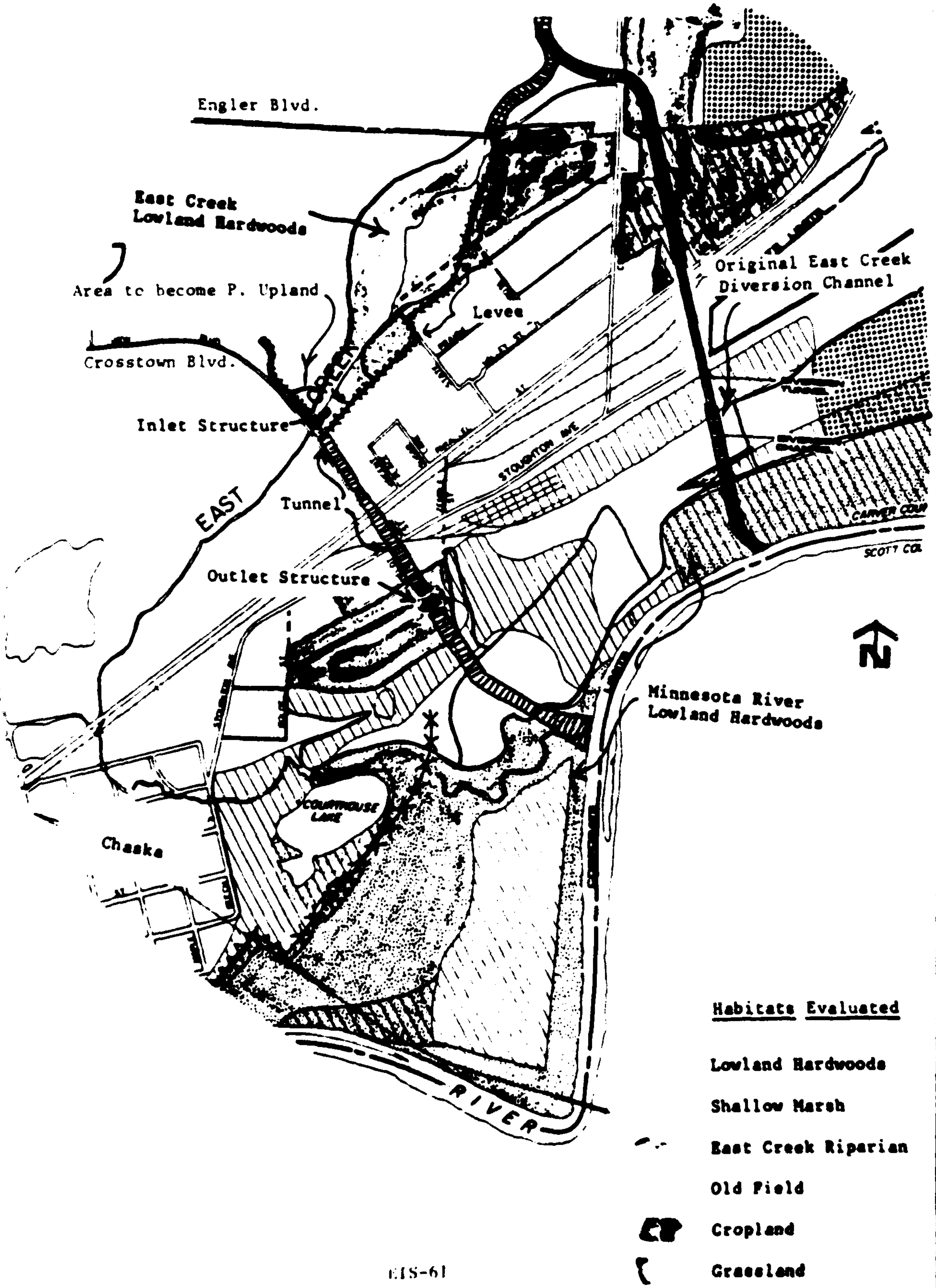
The revised design features are:

1. From Engler Boulevard upstream, a concrete channel 50 feet wide and 1500 feet long would be constructed.

2. A bridge would be constructed at Engler Boulevard.

3. Between Engler Boulevard and Crosstown Boulevard, East

Figure 1. Habitat types evaluated for the revised East Creek diversion channel. The original diversion channel alignment is shown for comparison. Locations of other habitats evaluated for the overall Chaska Flood Control Project are found on Figure 1 of the final FWCA report.


Engler Blvd.
East Creek
Lowland Hardwoods
Area to become P. Upland
Crosstown Blvd.
Levee
Inlet Structure
EAST
Tunnel
Outlet Structure
Original East Creek
Diversion Channel
STOUGHTON AVE
CARVER CO
SCOTT CO
Minnesota River
Lowland Hardwoods
COURTHOUSE LAKE
Chaska
RIVER
N
Habitats Evaluated
Lowland Hardwoods
Shallow Marsh
East Creek Riparian
Old Field
Cropland
Grassland

Creek would not be modified and the project would take advantage of the natural channel to retard the flow and dissipate the energy. To contain the flows within the natural channel, a levee would be constructed along the edge of the forested area on the south side of the existing channel. This levee would have a maximum height of 8 feet and an average height of 6 feet, and would be 4,000 feet long.

4. A 4-foot diameter pipe would replace the bridge at Crosstown Boulevard and would pass normal flows down the existing channel. Once the capacity of the pipe is reached, the flows would be diverted by means of a side-flow inlet structure into two 12-foot diameter concrete pipes. These pipes would convey the flows southeast under Crosstown Boulevard to beyond Bierline Avenue.

5. The outlet for the 12-foot pipes would be a concrete energy dissipator. The flow would then be conveyed by a trapezoidal grass-lined channel with a 32-foot bottom width and 1 vertical on 3 horizontal side slopes.

6. The channel would be flared 1 foot on 6 feet to reduce the

head on flows. Prior to reaching the Minnesota River, the outlet would contain a sheet-pile wall and riprap to prevent erosion.

SECTION II

Methods

II. Methods

The original habitat evaluation for the Chaska Flood Control Project was initiated in October, 1979 by a tri-agency team of biologists representing the Minnesota Department of Natural Resources, U.S. Army Corps of Engineers and U.S. Fish and Wildlife Service (FWS). With one exception, the revised East Creek diversion channel and levee were evaluated using study methods described in the final FWCA report. In the original habitat evaluation, data were entered into the FWS Hewlett Packard programable calculator using the standard HEP-76 program. However, study data for the revised East Creek diversion channel and levee were evaluated using the HEP-80 computer program (Stackowiak, 1982). The program format was modified from a species approach to the HEP-76 habitat approach by simply substituting habitat values for species values in the data input (Wege and Palesh, in press).

Three additional habitats not identified in the final FWCA report will be impacted by the revised East Creek diversion channel and levee. These habitats are identified as East Creek Riparian, Shallow Marsh, and East Creek Lowland Hardwoods (Figure 1). These habitats were not affected by the original project and were therefore not addressed in the final FWCA report. However, Shallow Marsh habitat

was evaluated by the tri-agency team in 1979 (USFWS 1981a). Evaluation species, numeral ratings and Habitat Unit Value (HUV) for this habitat are shown in Table 1.

Due to habitat similarity, evaluation species, numerical ratings and Habitat Unit Values used for East Creek Riparian and East Creek Lowland Hardwoods were taken from Chaska Creek Riparian and Lowland Hardwoods, respectively, contained in the final FWCA report. These and similar values for remaining habitats affected by the revised East Creek diversion channel and levee are found in the final FWCA report.

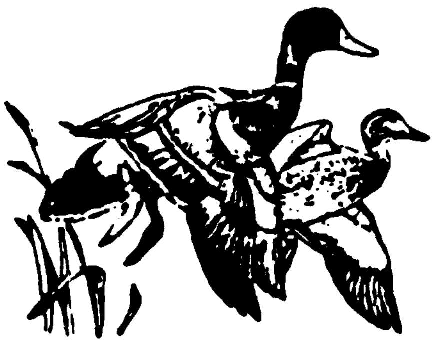
Table 1. Species used to evaluate Shallow Marsh habitat. Numbers shown are average numerical ratings for each species based on a scale of 0 - 10.0 and indicate the degree to which the habitat provides the essential life requirements for each species. The Habitat Unit Value (HUV) is the summation of the numerical ratings for the selected species. * indicates species selected from the <u>Draft Terrestrial Habitat Evaluation Criteria Handbook for Ecoregion 2213</u> (from USFWS, 1981a).

		Species									
Habitat Type	HUV	white-tailed deer *	least weasel *	meadow vole *	masked shrew *	ring-necked pheasant	common snipe *	common yellowthroat *	red-winged blackbird	song sparrow	marsh hawk *
Shallow Marsh	75	6.0	9.0	9.0	9.0	6.0	6.0	7.0	7.0	7.0	8.5

SECTION III

Description of Habitats Sampled

and Project Impacts



III. Description of Habitats Sampled and Project Impacts

The Chaska area contains a variety of habitats valuable to fish and wildlife. These areas are also used for public recreation such as wildlife observation and hiking. Most habitats within the project area are or have been influenced by the Minnesota River and East and Chaska Creeks. The following is a brief discussion of habitats that will be affected by the revised East Creek diversion channel and levee. Other habitats affected by the overall Chaska Flood Control Project are described in the final FWCA report. Habitat Unit Values (HUV) shown are from Table 1 and the final FWCA report. The locations of habitats affected by the revised East Creek diversion channel and levee are shown in Figure 1.

Old Field (HUV 81)

This typical field habitat is located northeast of Courthouse Lake and generally lies within the 100-year floodplain of the Minnesota River. Dominant vegetation includes staghorn sumac, willow, goldenrod, and grasses. A small pond is located in the area, with lowland hardwoods and shallow marsh bordering to the south and east. The revised East Creek diversion channel will take approximately 1.3 acres of Old Field habitat.

Shallow Marsh (HUV 75)

This wetland habitat can be described as Inland Fresh Meadow (Type 2 Wetland, Shaw and Fredine, 1956) or Palustrine Emergent Wetland (Cowardine, et al. 1979) and is located adjacent to the Minnesota River. Dominant vegetation includes reed canary grass and scattered shrubs. A portion of this wetland is interspersed with Old Field habitat. The revised East Creek diversion channel and outlet will directly impact approximately 3.1 acres of Shallow Marsh habitat for construction purposes. However, additional acreage could be affected if the proposed diversion channel causes secondary wetland drainage. Wetland drainage impacts associated with the diversion channel must be determined by District personnel. This information should be provided to the Service for use in preparation of the final supplemental report (refer to Section VI, Recommendation 4, page 26).

Lowland Hardwoods (HUV 57)

Typical lowland hardwood forest is located within the floodplain of the Minnesota River and East Creek. Dominant vegetation includes silver maple, cottonwood, willow and elm with scattered nettle, jewelweed and grasses. Along the Minnesota River, this habitat generally forms a continuous corridor within the study area. That

portion along East Creek is included as part of Lions Park which was purchased by the City of Chaska for recreational purposes using federal Land and Water Conservation Act funds (LAWCON). The revised East Creek diversion channel and levee will take approximately 1.4 and 3.2 acres of Lowland Hardwoods adjacent to East Creek and the Minnesota River, respectively.

East Creek Riparian (HUV 36)

This riparian habitat is located along the upstream portion of East Creek. Vegetation includes scattered elm, box elder, silver maple, cottonwood, willow and grasses. This habitat is similar to that found along Chaska Creek in residential areas. For purposes of this report, it is assumed that habitat impacts from the revised East Creek diversion channel and levee are confined to habitat upstream from the Engler Boulevard bridge. Approximately 1.7 acres of riparian habitat will be utilized.

Grassland (HUV 33)

This short, grassy habitat is found generally in developed areas along East Creek (i.e., Brandondale Subdivision, areas adjacent to Engler and Crosstown Boulevards). Approximately 2.6 acres of grassland habitat will be used in the construction of the revised

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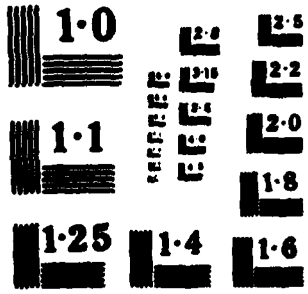
1·0
2·8
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East Creek diversion channel and levee.

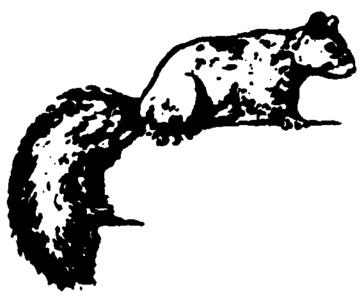
Cropland (EUV 29)

Two areas of cropland habitat will be affected by the revised project. These fields are located adjacent to more valuable wildlife habitats (Old Field, Shallow Marsh, Lowland Hardwoods) and provide some value to wildlife for food and cover. However, habitat values are reduced by fall plowing. The revised East Creek diversion channel and levee will result in the loss of approximately 6.1 acres of cropland.

SECTION IV

Management Recommendations

for Project Lands



IV. Management Recommendations for Project Lands

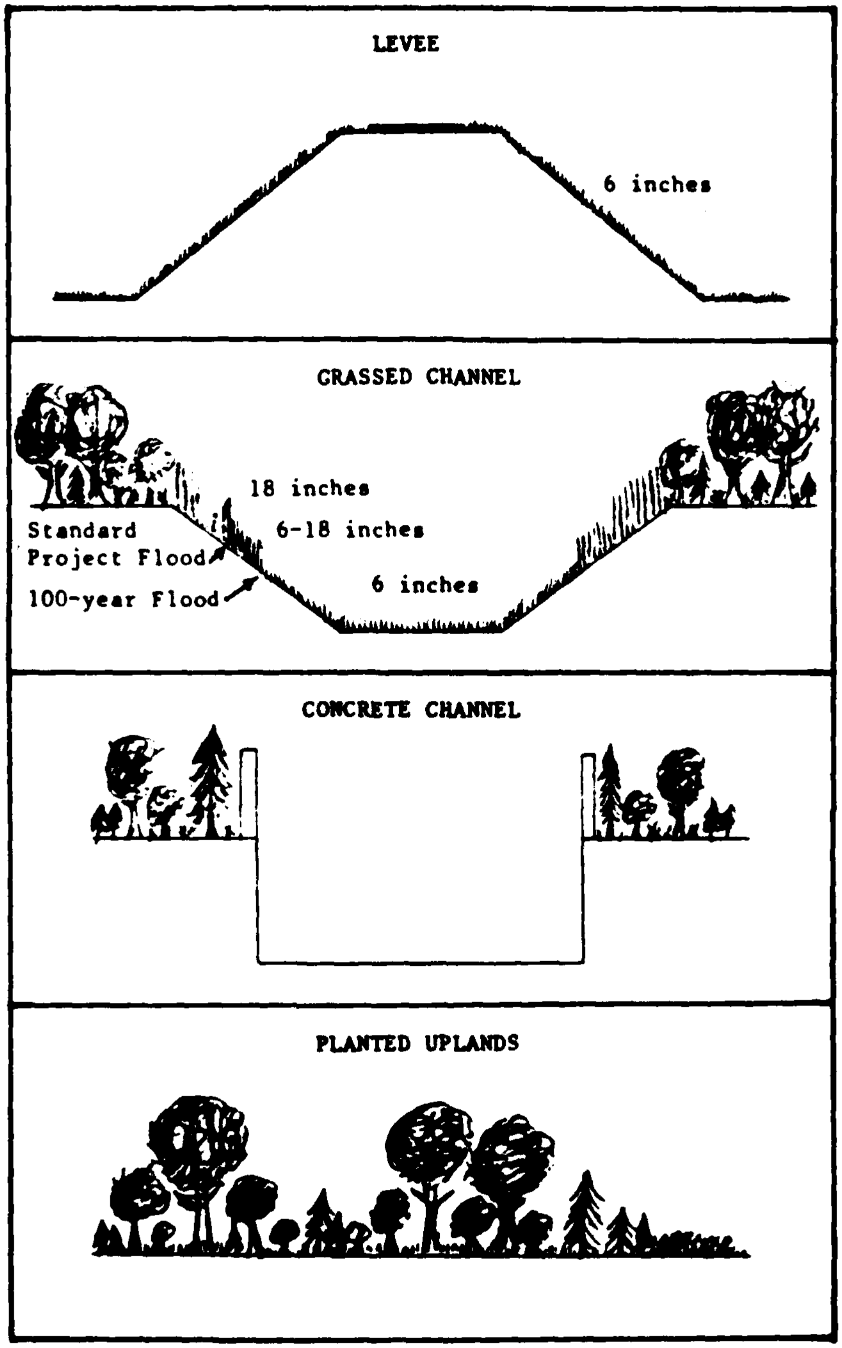
The following management recommendations are provided for the revised East Creek diversion channel and levee to improve project lands for wildlife uses and to minimize compensation requirements. These recommendations are consistant with those for other project features as outlined in the final FWCA report. Habitat Unit Values (HUV) assigned to these habitats are taken from the final FWCA report and are based on the adoption of these recommendations by the Corps as project features. Therefore, HUV's assigned to project lands can be considered as optimal values. Management recommendations illustrated in Figure 2 and HUV's illustrated in Figure 3 are from the final FWCA report.

East Creek Levee (HUV 37)

The proposed levee offers little opportunity for habitat improvement with future maintenance practices such as mowing, the use of herbicides, and planting constraints. However, the Service recommends the levee be seeded with legumes and grasses following construction. Levee maintenance practices should be avoided or minimized to improve levee habitat for wildlife use.

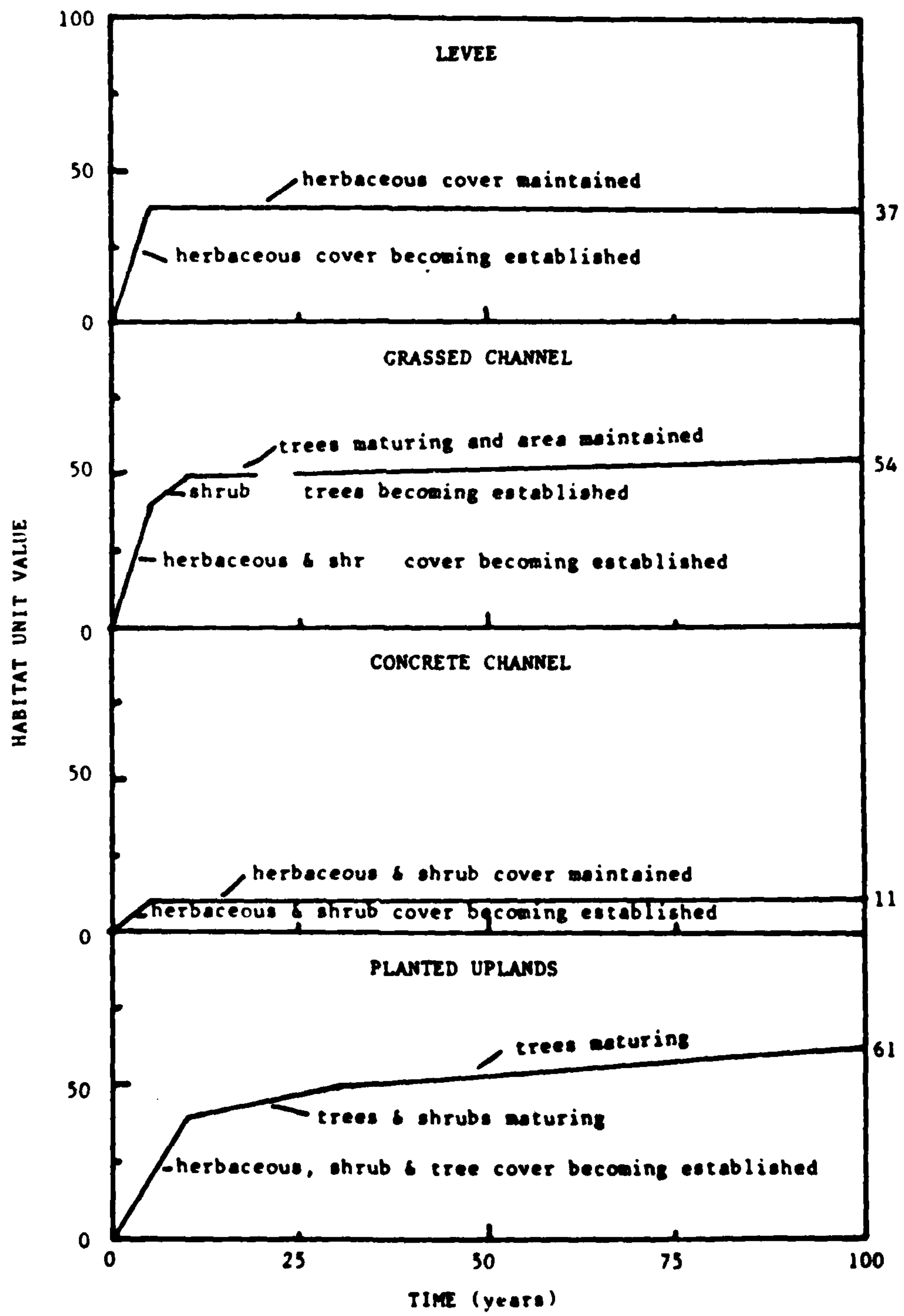
Given these management recommendations, Figure 3 shows the habitat

Figure 2. Illustration of habitat improvement measures for the Chaska Flood Control Project. Numbers shown for the levee and channel are the minimum recommended heights for maintaining vegetation.



Drawings Not To Scale

Figure 3. Habitat value of project lands for the Chaska Flood Control Project. Maximum habitat unit values for project lands were obtained from ratings shown in Table 1 of the final FWCA report.


LEVEE
herbaceous cover maintained
herbaceous cover becoming established
37
GRASSED CHANNEL
trees maturing and area maintained
shrub
trees becoming established
herbaceous & shr cover becoming established
54
CONCRETE CHANNEL
herbaceous & shrub cover maintained
herbaceous & shrub cover becoming established
11
PLANTED UPLANDS
trees maturing
trees & shrubs maturing
herbaceous, shrub & tree cover becoming established
61
HABITAT UNIT VALUE
100
50
0
0
25
50
75
100
TIME (years)

unit value for levee habitat over the project life of 100 years.

Grassed Channel (HUV 54)

A grassed channel is proposed for a portion of the revised East Creek diversion channel and outlet. There are several opportunities for habitat improvement along the waterway. Given constraints with respect to maintenance of the structure, the following habitat improvement measures are recommended:

(1) Areas within the channel proper should be seeded with grasses and legumes. Vegetation should be allowed to grow to the maximum height allowable under maintenance constraints (Figure 2).

(2) Shrubs such as willow and dogwood should be planted along the top of the channel banks. A variety of native tree species such as wild plum, choke cherry, cottonwood and maple should be planted in areas consistent with channel maintenance constraints. Plantings of small conifers are also recommended to provide winter cover.

(3) Mowing and application of herbicides for channel maintenance purposes should be avoided or minimized to

improve channel habitat for wildlife use. If necessary, a barbwire fence should be installed along the outer edge of the right-of-way to protect the habitat from grazing or other agricultural disturbances.

With the adoption of the above management recommendations, Figure 3 displays the Habitat Unit Value for grassed channel habitat.

Concrete Channel (HUV 11)

The proposed design of the concrete and riprap channel for portions of the revised East Creek diversion offers little opportunity for habitat improvement. However, the Service recommends plantings of native shrubs and small conifers along the channel banks to improve wildlife use and provide winter cover. Given these improvements, Figure 3 displays the Habitat Unit Value for concrete channel habitat.

Planted Uplands (HUV 61)

One area along East Creek approximately 0.2-acre in size offers the opportunity to improve project lands for wildlife use (Figure 1). There are no constraints placed on management recommendations since these lands require no maintenance from a structural standpoint. For

this area of planted uplands, the following habitat improvement measures are recommended:

(1) Shrubs and shrubby tree species such as dogwood, hazel and Russian olive should be planted in this area. A variety of native tree species such as oak, wild plum, choke cherry, maple and ash should also be planted. Plantings of small conifers are recommended to provide winter cover.

(2) The above area should be maintained and managed for wildlife purposes.

With the incorporation of the above recommendations, Figure 3 displays the Habitat Unit Value for planted uplands over the project life.

<u>Inlet Structure (HUV 0)</u>

Approximately 0.1-acre of riparian habitat along East Creek at the Crosstown Boulevard bridge will be used for construction of a concrete inlet structure. There is no opportunity to improve this structure for wildlife uses; consequently the structure was assigned a Habitat Unit Value of zero.

Other Project Lands

The Service also recommends that any other lands purchased for the project but not necessary from a structural standpoint be set aside and managed for wildlife uses, using the above recommendations for guidance. However, since the size and location of these areas is unknown at this time, resulting habitat gains cannot be considered in this habitat evaluation (refer to Section VI, Recommendation 2, page 24).

SECTION V

Quantification of Project Impacts

and

Determination of Compensation Recommendations

V Quantification of Project Impacts and Determination of Compensation Recommendations

Assumptions made concerning future with and without-project conditions for habitats evaluated for the revised project, and methods used to quantify habitat changes are those addressed in the final FWCA report. East Creek Riparian habitat was placed in Resource Category 3, per the FWS Mitigation Policy. Lowland Hardwoods and Shallow Marsh were placed in Resource Category 2; both are valuable wildlife habitats which are becoming scarce on a regional and national basis.

Future with-project conditions for the revised East Creek diversion channel and levee are shown in Table 2. Gross habitat losses for the revised East Creek diversion channel and levee are 19.4 acres and -918.0 Habitat Units (HU) compared to 16.5 acres and -652.9 HU for the original alignment. Total net loss of Resource Category 2 and 3 habitats for the overall revised Chaska Flood Control Project are -1250.3 HU and -913.4 HU, respectively (Table 3). Total gains from management proposals used to offset losses to non-wetland Resource Category 3 habitats are +148.7 HU. Total losses for the revised Chaska Flood Control Project to be compensated are -2015.0 HU as compared to -1627.5 HU for the original project. It should be noted that habitat gains applied to offset losses are due, for the most

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Table 2. Annualized habitat units lost and gained from construction of the revised Chaska Flood Control Project. Habitat units lost and gained for the original East Creek diversion channel are also shown for comparison with the revised project. Changes in habitat units[1] were used in determining compensation needs in Table 4 and are explained in Section VI of the final FWCA report. Habitat units displayed in this table were annualized in the HEP-80 computer program and are not simply the product of acres and habitat unit values (HUV). HUV's for habitats gained are maximum values from implementation of the recommended habitat improvement measures in Section IV and displayed in Figure 3 of this report and the final FWCA report.

	Habitat Lost					Habitat Gained					
	Habitat Type	Resource Category	Acres	HUV	Habitat Units	Habitat Type	Resource Category	Acres	HUV	Habitat Units	Change in Habitat Units[1]
Original E. CREEK	Lowland Hwds.	2	-6.0	57	-338.8	G. Channel	3	+6.0	54	+299.1	-338.8
	Grassland	4	-2.8	33	-91.9	G. Channel	3	+2.8	54	+139.6	+47.7
	Cropland	4	-7.7	29	-222.2	G. Channel	3	+7.7	54	+383.8	+161.6
Revised E. Creek	E. Cr. Riparian	3	-1.7	36	-61.0	C. Channel	4	+1.7	11	+18.0	-61.0
	Lowland Hwds.E.Cr.	2	-1.3	57	-73.0	Levee	4	+1.3	37	+48.0	-73.0
	Lowland Hwds.E.Cr.	2	-0.1	57	-6.0	Inlet	4	+0.1	0	0.0	-6.0
	Old Field	3	-1.3	81	-105.0	G. Channel	3	+1.3	54	+64.0	-41.0
	Shallow Marsh	2	-3.1	75	-231.0	G. Channel	3	+3.1	54	+155.0	-231.0
	Cropland	4	-1.9	29	-55.0	C. Channel	4	+1.9	11	+20.0	-35.0
	Cropland	4	-2.6	29	-76.0	G. Channel	3	+2.6	54	+130.0	+54.0
	Cropland	4	-1.6	29	-45.0	Levee	4	+1.6	37	+57.0	+12.0
	Lowland Hwds.MN.R.	2	-3.1	57	-176.0	G. Channel	3	+3.1	54	+155.0	-176.0
	Lowland Hwds.MN.R.	2	-0.1	57	-5.0	C. Channel	4	+0.1	11	+1.0	-5.0
	Grassland	4	-2.4	33	-78.0	Levee	4	+2.4	37	+85.0	+7.0
	Grassland	4	-0.2	33	-7.0	P. Uplands	3	+0.2	61	+10.0	+3.0
C. CREEK	I. Riparian	3	-4.6	73	-334.1	P. Uplands	3	+4.6	61	+228.4	-105.7
	I. Riparian	3	-2.0	73	-145.3	C. Channel	4	+2.0	11	+21.3	-145.3
	Lowland Hwds.	2	-1.7	57	-96.0	P. Uplands	3	+1.7	61	+84.4	-96.0
	C. Cr. Riparian	3	-1.4	36	-49.4	P. Uplands	3	+1.4	61	+69.5	+20.1
	C. Cr. Riparian	3	-0.6	36	-21.2	C. Channel	4	+0.6	11	+6.4	-21.2
	Old Field[2]	3	-1.25	81	-90.5	C. Channel	4	+1.25	11	+13.3	-90.5
	Lowland Hwds.[2]	2	-1.25	57	-79.5	C. Channel	4	+1.25	11	+13.3	-79.5
LEVEE	Old Field	3	-2.3	81	-184.2	Levee	4	+2.3	37	+82.6	-184.2
	F. Wetland	3	-3.5	74	-257.7	Levee	4	+3.5	37	+125.6	-257.7
	Lowland Hwds.	2	-6.1	57	-344.5	Levee	4	+6.1	37	+218.9	-344.5
	Grassland	4	-16.3	33	-535.2	Levee	4	+16.3	37	+585.0	+49.8
	Cropland	4	-0.4	29	-11.6	Levee	4	+0.4	37	+14.4	+2.8
	Lowland Hwds.	2	-3.9	57	-220.2	P. Uplands	3	+3.9	61	+193.6	-220.2
	Old Field[2]	3	-0.3	81	-21.7	P. Uplands	3	+0.3	61	+14.9	-6.8
	Lowland Hwds.[2]	2	-0.3	57	-19.1	P. Uplands	3	+0.3	61	+14.9	-19.1

[2] This portion of the Minnesota Valley National Wildlife Refuge is presently old field habitat reverting to lowland hardwoods. Habitat units lost from the Chaska Creek diversion channel and levee were determined to be losses to old field and lowland hardwoods over the project life. Refer to Section V of text.

part, to habitat improvement recommendations for project lands as described in Section IV of this report. If these recommendations are not adopted by the Corps of Engineers as an integral part of the Chaska Flood Control Project, total losses to be compensated will be in excess of -2015.0 HU.

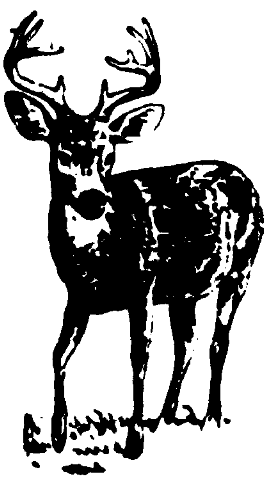
Table 3. Summary of compensation needs for the original and revised Chaska Flood Control Project. Habitat units gained were applied to offset losses to Resource Category 3 habitats. Compensation is needed to replace a total loss of -2015.0 habitat units for the revised project as compared to -1627.5 habitat units for the original project. (refer to Section V of text and Table 2).

Resource Category	Habitat Units Lost		Habitat Units Gained	
	Original	Revised	Original	Revised
2	-1098.1	-1250.3	0	0
3	-811.4	-913.4	+20.1	+20.1
4	0	-35.1 [1/]	+261.9	+128.6

[1/] USFWS Mitigation Policy does not require compensation for losses to Resource Category 4 habitats.

SECTION VI

Compensation Recommendations



VI Compensation Recommendations

The overall revised Chaska Flood Control Project will result in the loss of -2015.0 HU as compared to -1627.5 HU for the original project, a difference of -387.5 HU. Net losses in Habitat Units are greater for the revised project primarily because:

1. Fewer acres of cropland and grassland habitat will be used for construction of a grassed channel. Conversion of cropland and grassland habitat to grassed channel results in a per acre gain in habitat units through implementation of habitat recommendations in Section IV. The habitat gains can then be used to offset other habitat losses. For example, 10.5 acres of cropland and grassland habitat were converted to grassed channel for construction of the original East Creek diversion channel. Resulting habitat improvements of +209.3 HU were subsequently used to offset other habitat losses. For the revised project, only 2.6 acres of cropland and grassland habitats will be converted to grassed channel with a similar habitat improvement of only +54.0 HU.

2. The original alignment for the East Creek diversion channel was designed to avoid impacts to Shallow Marsh habitat

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along the Minnesota River and U.S. Highway 212. Unfortunately, the revised project will result in the loss of 3.1 acres and -231.0 HU of Shallow Marsh habitat, thereby increasing overall habitat losses.

3. Unlike the original project, a levee is also proposed along East Creek which will result in losses to Lowland Hardwoods. Although the total loss to Lowland Hardwood habitat is 4.6 acres and -260.0 HU for the revised project compared to 6.0 acres and -338.8 HU for the original project, the additional loss of -231.0 HU of Shallow Marsh increases the net loss of Resource Category 2 habitat for the revised project by -152.2 HU.

As stated in the August, 1982 Limited Reevaluation Report and Final Supplement to the Final Environmental Impact Statement, Compensation Proposal A as recommended by the Service in the final FWCA report was included as a feature of the Chaska Flood Control Project by the Corps of Engineers (Corps of Engineers, 1982). This compensation plan involves construction of a water control structure on Chaska Lake and development of a moist soil management unit. Both features are located adjacent to the City of Chaska on the Chaska Lake Unit of the Minnesota Valley National Wildlife Refuge. Implementation of this compensation plan would provide +1786.0 HU. This was adequate

compensation for habitat losses of -1627.5 HU associated with the original Chaska Flood Control Project. However, when compared to the net loss of -2015.0 HU for the revised project, there is now a need to compensate for an additional -229.0 HU.

The following recommendations are provided in an attempt to further reduce project impacts to wildlife resources and, if necessary, compensate for any additional habitat losses associated with the revised Chaska Flood Control Project. These recommendations are intended to supplement those contained in the final FWCA report and implementation of Compensation Proposal A by the Corps of Engineers as an integral part of the Chaska Flood Control Project.

Recommendation 1

The Fish and Wildlife Service recommends the revised East Creek diversion channel be reduced in scope to avoid and minimize impacts to valuable habitats. The revised East Creek diversion channel project evaluated in this report is the second revision to the original project. The first revision (Revision 1) was provided for Service review approximately 1 week before the second revision (Revision 2). Revision 1 involves the following features:

1. At the upstream end of the diversion channel, there would

be a 45-foot wide drop structure constructed at Brandon Boulevard.

2. From the drop structure at Brandon Boulevard to Engler Boulevard, the channel would be modified to a grass-lined trapezoidal channel with a 45-foot bottom width and 1 vertical to 3 horizontal side slopes.

3. A bridge would be constructed at Engler Boulevard.

4. Between Engler Boulevard and Crosstown Boulevard, East Creek would not be modified, and the project would take advantage of the natural channel to retard the flow and dissipate the energy. To contain the flows within the natural channel, a levee would be constructed along the edge of the forested area on the south side of the existing channel. This levee would have a maximum height of 8 feet and an average height of 6 feet, and would be 4,000 feet long.

5. A 4-foot diameter pipe would replace the bridge at Crosstown Boulevard and would pass normal flows down the existing channel. Once the capacity of the pipe is reached, the flows would be diverted by means of a

side-flow inlet structure into two 12-foot diameter concrete pipes. These pipes would convey the flows southeast under Crosstown Boulevard to beyond Bierline Avenue.

6. The outlet for the 12-foot pipes would be a concrete energy dissipator. The flow would then be conveyed by a trapezoidal grass-lined channel with a 32-foot bottom width and 1 vertical on 3 horizontal side slopes.

7. About 500 feet upstream from the Lowland Hardwoods along the Minnesota River, the channel would be flared at 1 foot on 6 feet to reduce the head on the flows.

8. The channel would be ended prior to reaching the Lowland Hardwoods with a sheet-pile wall and riprap to prevent erosion.

There are two major differences between Revisions 1 and 2 with respect to habitat losses:

1. Revision 1 would utilize a grass channel for portions of East Creek upstream from Eagler Boulevard; Revision 2 would utilize a longer section of concrete channel having little

habitat value.

2. Revision 1 would terminate the diversion channel approximately 700 feet inland from the Minnesota River, thereby avoiding impacts to Lowland Hardwoods; Revision 2 would use 3.2 acres of Lowland Hardwoods and terminate the diversion channel at the Minnesota River.

A similar habitat evaluation was performed for Revision 1. Net loss in habitat units for the overall Chaska Flood Control Project with Revision 1 are -1847.0 HU compared to -2015.0 HU with Revision 2 (Table 4). Due to fewer habitat losses associated with Revision 1, additional compensation is needed for only -61.0 HU in contrast to -229.0 HU for the flood control project with Revision 2. Based on fewer habitat losses, the Fish and Wildlife Service recommends that the St. Paul District reevaluate Revision 1 for implementation as part of the overall Chaska Flood Control Project.

Recommendation 2

Due to the time constraints placed on developing the recent revisions to the original East Creek diversion channel, detailed information on location, design and lands necessary for project purposes have been limited or unavailable for use in this habitat evaluation. This is

Table 4. A comparison of compensation needs between Revision 1 and 2 of the Chaska Flood Control Project. Habitat units gained were applied to offset losses to Resource Category 3 habitats. Compensation is needed to replace a total loss of -1847.0 habitat units for Revision 1 and -2015.0 habitat units for Revision 2.

Resource Category	Habitat Units Lost		Habitat Units Gained	
	Revision 1	Revision 2	Revision 1	Revision 2
2	-1189.3	-1250.3	0	0
3	-830.4	-913.4	+40.1	+20.1
4	-8.0 1/	-35.0	+132.6	+128.6

1/ USFWS Mitigation Policy does not require compensation for losses to Resource Category 4 habitats.

especially true for Revision 2. In particular, maps showing lands necessary for construction, operation and maintenance of the project would be useful in identifying those lands which could be improved for wildlife uses; resulting gains in habitat values could be used to further reduce project impacts. For example, cropland or grassland areas adjacent to the levee and diversion channel which are necessary for project purposes may also be available for habitat improvement measures. If enough acreage were involved, resulting habitat gains could reduce project impacts to the point of compensating for remaining habitat losses associated with the revised project. The Service therefore recommends that such lands be identified by the District and that measures be taken to maximize habitat improvement of these lands. This information should also be provided to the Service so the final habitat evaluation can be adjusted accordingly, to incorporate any such habitat gains.

Recommendation 3

If a substantial net loss in habitat units continues to occur for the revised Chaska Flood Control Project beyond action taken by the St. Paul District with respect to Recommendations 1 and 2 above, the Fish and Wildlife Service recommends these losses be adequately compensated through additional habitat improvement measures. At present, the revised flood control project with Revision 2 will

necessitate compensation for an additional -229.0 HU. In an attempt to avoid the necessity for additional compensation measures, we again recommend all measures be taken to avoid and minimize habitat impacts by selecting a more environmentally acceptable project such as Revision 1. In addition, enhancement of other project lands for wildlife uses should be maximized to offset additional habitat losses from the revised project.

In the event a substantial net habitat loss continues to occur for the revised project, there are several opportunities available for additional habitat improvement measures. One option available to the District is the selection of an additional compensation plan identified in the final FWCA report (Table 5). For example, development of the impoundment listed in Table 5 would provide an additional 680 HU for compensation. Another possibility may be habitat improvement measures on other refuge lands or lands owned by the City of Chaska. If necessary, additional compensation measures will be recommended in the final supplemental report.

Recommendation 4

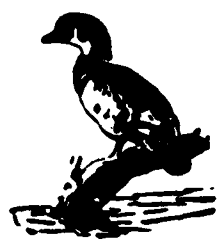
This report assumes that only 3.1 acres of Shallow Marsh will be impacted from construction of the revised East Creek diversion channel. However, since this channel will effectively bisect this

Table 5. Acreage, habitat unit values (HUV), management potential, and annualized gain in habitat units for compensation projects on the Minnesota Valley National Wildlife Refuge. Compensation Proposal A selected by the Corps of Engineers includes construction of the water control structure on Chaska Lake and moist soil unit for a total gain of +1786.0 habitat units.

Project	Acres	Existing HUV	Management Potential[1/]	HUV With Mgmt.	Total Habitat Units Gained
Moist Soil Unit	19	29	40	69	760
Impoundment	17	29	40	69	680
Water Control Structure					
Chaska Lake	57	58	18	76	1026
Type III Wetland	80	79	10	89	800
Louisville Swamp	200	73	10	83	2000

[1/] Habitat units gained through management/acre/year.

habitat, secondary impacts associated with wetland drainage are possible. The St. Paul District should determine the extent of any such wetland drainage associated with construction of the proposed channel through wetland habitat. This information should be provided to the Service for incorporation into the final supplemental report.



SECTION VII

References

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VII References

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Stackowiak, R.C. 1982. Habitat evaluation procedures accounting program for Harris computers (HEP-H). U.S. Army Corps of Engineers, St. Paul District, Minnesota.

U.S. Fish and Wildlife Service. 1981a. Planning aid report: habitat evaluation of alternatives for the Chaska Flood Control Project.

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U.S. Fish and Wildlife Service, St. Paul Field Office, Minnesota. 10 pp. plus appendices.

U.S. Fish and Wildlife Service. 1981b. Draft Fish and Wildlife Coordination Act report for Chaska Flood Control Project. U.S. Fish and Wildlife Service, St. Paul Field Office, Minnesota. 30 pp. plus appendices.

LIST OF RECIPIENTS

The following agencies, organizations, and individuals will receive copies of supplement II to the FEIS or a notice of its availability.

United States Senators

Honorable David Durenberger
Honorable Rudy Boschwitz

United States House of Representatives

Honorable Thomas Hagedorn
Honorable Bill Frenzel

Governor of Minnesota

Honorable Albert H. Quie

State Senators

Honorable Robert Schmitz

State Representatives

Honorable K.J. MacDonald

Federal Agencies

United States Department of the Interior
Assistant Secretary for Program Policy
United States Fish and Wildlife Service, Field Office
United States Fish and Wildlife Service, Regional Office
United States Fish and Wildlife Service, Minnesota Valley National Wildlife Refuge
Acting Assistant Director, United States Geological Survey
United States Geological Survey, Conservation Division, Area Water Power
Bureau of Indian Affairs
National Park Service
Interagency Archaeological Services

United States Department of Transportation
Federal Highway Administration
Second Coast Guard District

EXHIBIT 4

United States Department of Agriculture
Eastern Region Forest Service
United States Forest Service
Soil Conservation Service, River Basin Planning Branch
Soil Conservation Service, Minnesota State Conservationist
Agriculture Stabilization and Conservation Service

United States Department of Commerce
Deputy Assistant Secretary for Environmental Affairs
Deputy Assistant Secretary for Regulatory Policy
Economic Development Representative, Duluth, Minnesota
National Oceanic & Atmospheric Administration
- National Marine Fisheries Service
- National Weather Service

United States Department of Health and Human Services
Director of Environmental Affairs
Region V Environmental Office
Public Health Service

United States Department of Housing and Urban Development
Region V Environmental Clearance Officer
Regional Administrator, Federal Housing Authority

United States Department of Energy
Federal Energy Regulatory Commission
Division of NEPA Affairs

United States Environmental Protection Agency
Region V Administrator
Office of Federal Activities

Federal Emergency Management Administration

Advisory Council on Historic Preservation
Executive Director

U.S. Postal Service
Postmaster, Chaska

Minnesota State Offices and Agencies

Minnesota Senate
Minnesota State House of Representatives
Office of Economic Opportunity
Minnesota Department of Agriculture
Minnesota Energy Agency
Minnesota State Historic Preservation Office
Minnesota State Archaeologist
Environmental Quality Board

Environmental Quality Board, Citizen's Advisory Committee
Minnesota Pollution Control Agency
Minnesota Department of Transportation
Minnesota Department of Energy, Planning, and Development
Minnesota Department of Health, Division of Environmental Health
Minnesota Department of Natural Resources
Minnesota State Board of Health
Water Resources Board, Administrative Secretary
Minnesota-Wisconsin Boundary Area Commission
Natural Resources and Agriculture Senate Committee

Regional, County, Local Agencies

City of Chaska, Mayor
City Administrator, Chaska
City of Chaska, Director of Public Works
City Engineer, Chaska
Carver County Board
Metropolitan Council
Southern Minnesota River Basins Commission
Southern Minnesota River Watershed District
Minnesota Valley Trails

Libraries

Chaska Public Library
Minneapolis Public Library
St. Paul Public Library
Metro Council Library
Hill Reference Library
University of Minnesota Library
Colorado State University Library

Newspapers, Media

Carver County Herald
Sun Newspapers
Minneapolis Star and Tribune
Waterways Journal

Interest Groups and Individuals

Chaska Chamber of Commerce
Chaska Citizens' Advisory Committee
Friends of the Earth, Minnesota Branch
Izaak Walton League of America
Izaak Walton League, Minneapolis Chapter
Ducks Unlimited
Minnesota Environmental Education
Minnesota Environmental Control Citizens Association

Minnesota Public Interest Research Group
Sierra Club, North Star Chapter
Minnesota League of Women Voters
Soil Conservation Society of America
Environmental Defense Fund, Inc.
National Audubon Society, North Midwest Region
National Audubon Society, North Midwest Representative
National Wildlife Federation
Midwestern Gas Transmission
Minnesota League of Women Voters
Chicago-Milwaukee Corporation, Chicago, Illinois
Private individuals (approximately 400)

APPENDIX A

HYDROLOGY AND HYDRAULICS

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PLATES

HYDROLOGY

INTRODUCTION

1. For the general design memorandum, a modified location of the diversion structure on East Creek was analyzed for existing, future and project condition. Modified portions from the limited reevaluation report include Flood Routing Model and Standard Project Floods.

FLOOD ROUTING MODEL

2. An HEC-1 computer model was developed to perform flood routings. Initially, after the Snyder's unit hydrograph coefficients were determined, the 5-minute unit hydrographs were developed for each of the subwatersheds. A time interval of 30 minutes was used as the computation time interval. This time interval was selected because the hydrograph peaks are delayed considerably due to hydraulic routing through the reservoirs in the watersheds and because of the constraint of a limited number of computation time increments allowed by the computer model. The 30-minute unit hydrographs were developed from the 5-minute unit hydrographs using S-curve techniques. These hydrographs were adjusted slightly to provide a peak discharge, similar to those obtained using the 5-minute unit hydrographs.

3. The runoff was computed using the information compiled from each subwatershed. The amount of rainfall analyzed in each watershed was adjusted on the basis of the total tributary drainage area using the drainage area-rainfall relationship. In watersheds where reservoir routing was required, stage-discharge relationships were developed for the various outlet structures. Storage behind the structures was estimated from topographic maps. These relationships were adjusted to reflect existing conditions. Culverts and waterway openings were obtained from field measurements. Channel routing was computed by estimating the time lag from each subwatershed to the next subwatershed, and storage-discharge relationships were developed using length of the watercourse, typical cross sections, and Manning's equation. No alterations to the existing reservoirs or channels were assumed for future development of the subwatershed.

4. The storage-elevation and outflow rating curves were developed for the existing Lake Grace Dam and Reservoir. The outflow rating curve was developed on the basis of field observations because no outflow rating curve was available.

5. The outlet rating curve for subwatershed EC-2 was simplified. The tailwater below the outlet of EC-2 was assumed to be at the same elevation as the Lake Grace pool. This assumed that a significant head loss across the 20-foot diameter pipe immediately upstream of the Lake Grace Dam does not occur.

6. The peak discharges for existing and future conditions for various frequency storms at the outlets of the subwatershed of Chaska and East Creeks are presented in the following tables. The discharge-frequency curves for Chaska Creek and East Creek for existing and future conditions are presented on plate 4A-7 and 4A-8, respectively in the limited reevaluation report.

7. The flood hydrographs at Highway 212 for existing and future conditions on Chaska Creek are shown on plate 4A-9 to 4A-18 in the limited reevaluation report.

8. Flood hydrographs for East Creek for existing and future deve opment are presented on plates A-2 to A-13. The East Creek flood hydrographs are presented for two locations: 1) East Creek upstream of Lake Grace; and 2) the location of the proposed diversion structure.

9. Flood frequency relationships were also developed for the East Creek watershed under project conditions. Highway 41, which crosses East Creek at the outlet of EC-8, will have the present culvert replaced by a bridge. Because of the amount of fill that will be removed with the culvert, it was assumed that the bridge opening could pass the standard project flood. Additional computer runs were made to determine the effect at the proposed diversion location. The future condition watershed characteristics were assumed, with the reservoir storage effect of the Highway 41 embankment removed from the model.

10. It was found that significant storage occurs above Lake Grace and contributes flow on the flood recession at the proposed diversion location. Subwatershed hydrographs for EC-7, EC-8 and EC-9 were routed and combined using channel storage parameters for all of EC-10. This resulting hydrograph was combined with the EC-10 subwatershed hydrograph modified to reflect the 295 acres above the proposed diversion location by a drainage area ratio of 0.65. A better channel storage relationship in EC-10, coupled with an improved unit hydrograph determination for the 295 acres should be accomplished in the Feature DM. Hydrographs reflecting project conditions with Highway 41 bridge in place are shown on plates A-14 through A-16.

STANDARD PROJECT FLOODS

MINNESOTA RIVER AT CHASKA

11. A standard project flood has previously been derived for the Minnesota River near Carver. This standard project flood has a peak of 168,000 cfs. The derivation is given in "Report on Probable Maximum Floods and Standard Project Floods for Minnesota River Basin, Minnesota," by the St. Paul District Office, dated January 1971. This peak value was based on an adopted standard project flood at Mankato of 155,000 cfs and drainage area relationships of peak flows for floods of record. The drainage area at the Mankato gage, 14,900 square miles, is 8 percent less than that at the Carver gage. The Mankato standard

project flood was determined in a lengthy investigation of the Minnesota River basin, which involved dividing the basin into seven subareas and using routing and combining procedures. Floods were computed for the all-season (summer) storm and various combinations of spring snowmelt and rainfall runoff. The adopted standard project flood at Mankato, 155,000 cfs, is from a combination of rainfall immediately following the snowmelt runoff.

12. The drainage area of the Minnesota River at Chaska, shown on plate 1 of the main report, is approximately 16,600 square miles while that at the Carver gaging station is 16,200 square miles. The standard project flood drainage area line from Mankato to Carver, on plate 27 of the above mentioned report, was extended to 16,600 square miles. This line represents approximately the 0.7 power of the drainage area ratio. The standard project flood for the Minnesota River at Chaska is then determined to be 168,000 cfs.

CHASKA CREEK AND EAST CREEK

13. The standard project flood was determined for the East Creek and Chaska Creek watersheds. The HEC-1 model described in the previous sections of this report was used for this analysis. Unit hydrographs and runoff coefficients previously developed for existing and future conditions were also used for the development of the standard project flood. The standard project storm was computed in accordance with EM 1110-2-1411, "Standard Project Storm Determinations." The standard project storm index rainfall for the Chaska, Minnesota, area was determined to be 10 inches. The standard project storm option of the HEC-1 computer model was used to obtain the 96-hour storm pattern in hourly increments. The precipitation was then reduced by the "Hop Brook" factor as described in EC 1110-2-163 (Draft Engineering Manual), "Spillway and Freeboard Requirements for Dams." This reduction was 19.5 percent for East Creek and 18.7 percent for Chaska Creek. The half hour incremental precipitation was developed by plotting the mass precipitation versus time and interpolating the half hour increments.

14. Because of the constraints of the computer model, only the most severe 72 of the 96-hour storm were modeled. In the East Creek basin, 0.27 inch of precipition fell with the first 24 hours of the 96-hour standard project storm and was not modeled. This precipitation can be expected to contribute to initial losses and not contribute to the peak. During the same time period, 0.28 inch fell in the Chaska Creek watershed. In the remaining 72 hours, 11.67 inches fell in the East Creek watershed and 11.53 inches in the Chaska Creek watershed. The drainage area-rainfall depth relationships used were computed from the EM 1110-2-1411.

15. The peak discharges from each of the subwatersheds in Chaska Creek and East Creek for existing and future conditions are presented in the following table. The flood hydrographs for the standard project flood at the mouth of the West Branch Chaska Creek and Chaska Creek at U.S.

Highway 212 are shown on plate 4A-19 for existing conditions and plate 4A-20 for future conditions in the limited reevaluation report. The locations of the hydrogrphs presented are upstream of Lake Grace and East Creek at the diversion.

Table A-1

Standard Project Storm Peak Discharge

Chaska Creek			East Creek		
Sub-Watershed	Existing Condition	Future Condition	Sub-Watershed	Existing Condition	Future Condition
7	1,580	2,000	1	80	80
6	2,140	2,420	2	1,470	1,580
5	200	205	3	865	1,230
4	670	680	4	365	390
3A	505	520	5	40	41
3	2,200	2,570	6	1,750	2,340
2	2,500	2,920	7	1,940	2,800
1A	2,260	2,800	8	2,740	3,300
1	4,700	5,550	9	3,780	4,080
1Z		6,050	10	3,800	(1)
			11	3,850	(1)

(1) Future conditions for East Creek subwatersheds 10 and 11 are presented in table 4C-9 in the limited reevaluation report.

Table A-2

Peak Discharges at Proposed East Creek Diversion Location

	2-yr. Storm	5-yr. Storm	10-yr. Storm	25-yr. Storm	50-yr. Storm	100-yr. Storm	500-yr. Storm	SPF
Existing Conditions	900	1,350	1,700	2,070	2,430	2,830	3,300	3,900
Future Conditions	1,020	1,620	1,970	2,400	2,730	3,130	3,600	4,300
Project Conditions	-	-	-	-	-	4,200	4,950	6,220

Note 2- through 50-year storms will be determined as part of the feature design memo hydrologic studies.

16. Standard project flood runoff from subarea 1Z, Chaska Creek watershed, located downstream of Highway 212 and emptying into the supercritical channel was analyzed as follows.

17. The drainage basin characteristics for subarea 1Z were measured. The drainage area is .34 square mile, the channel length is 5,700 feet, the slope is 3.86%, and the length to centroid is 3,770 feet. The subarea 1A characteristics were compared with characteristics for other Chaska Creek subareas of similar size. It was found that subarea 3A most closely compared with subarea 1Z characteristics. The flows for subarea Z were computed based on flows for subarea 3A multiplied by the drainage area ratio $(.34/.65)^{.7}$. The computed flows for subarea 1A were routed through the storage area at its outlet and combined with the flows on the mainstem of Chaska Creek. The peak standard project flood flow on the main stem of Chaska Creek is 5,550 cfs. The peak SPF flow on the main stem increases to 6,050 cfs after combining with SPF runoff from subarea 1Z. This combined flow of 6,050 cfs was used to design the Chaska Creek channel.

HYDRAULIC DESIGN

GENERAL

18. The proposed project will consist of channel modifications, levees, control structures, a diversion conduit and erosion protection. The hydraulic design for the proposed Chaska Creek diversion and the proposed Minnesota River levee presented in this appendix is developed to a level of detail more than adequate for this report. However, the level of detail for the hydraulic design of the proposed East Creek diversion channel is such that a portion of the design details will be developed during the feature design hydraulic studies. Because of the difference in the level of hydraulic design detail, these three features are presented separately in this appendix. The hydraulic design for the proposed Minnesota River levee from the limited reevaluation report has been reviewed and no significant changes will be made in this report. But the hydraulic designs for the proposed diversion channels on East and Chaska Creeks have major changes in the design concepts. The Chaska Creek diversion channel has changed from a tranquil flow to a rapid flow channel design. The East Creek diversion channel alignment has changed resulting in features different from those in the limited reevaluation report. These details will be explained in the individual sections for each design feature.

HYDRAULIC DESIGN
MINNESOTA RIVER

19. The hydraulic design for the proposed Minnesota River levee presented in the limited reevaluation report is developed to the level of detail adequate for this memo. The proposed levee will provide protection from the 1-percent chance flood. A review of the previous hydraulic design resulted in a minor adjustment to the proposed top of levee profile. Full details for the hydraulic design of the proposed levee are presented in the limited reevaluation report. The design of

the top of levee profile is briefly reviewed here. The proposed top of levee profile was developed by selecting a discharge from the rating curve at the downstream end of the project 3 feet above the computed design water surface profile then backwatering this discharge. Because of the wide floodplain at Chaska and backwater effects from the Mississippi River, the computed profile for this discharge attenuates in the upstream direction. This results in a difference between the computed design water surface profile and the computed profile for this discharge at the upstream end of the project of 2.84 feet. The proposed top of levee profile shown in this report was adjusted so that the levee elevation is not less than 3 feet above the computed design water surface profile at any place along the levee to insure overtopping at the downstream end as discussed in the limited reevaluation report. Other details for the Minnesota River at Chaska such as existing water surface profiles can be found in the limited reevaluation report.

HYDRAULIC DESIGN
CHASKA CREEK

GENERAL

20. The proposed design for Chaska Creek consists of an ogee inlet structure, a 0.9 mile long concrete rectangular channel and a Saint Anthony Falls type stilling basin at the outlet. The channel is designed to provide protection from the standard project flood on Chaska Creek, the design discharge is 5550 cfs upstream of the drainage inlet at channel station 37+50 and 6050 cfs downstream of this inlet. The concrete channel is to flow supercritical with generally the same alignment as the limited reevaluation report. The inlet ogee structure and approach channel are designed to provide a smooth entrance into the supercritical channel and to raise the lowered water surface and channel bottom in the project area to match the pre-project existing conditions water surfaces and thalweg upstream of the project. The outlet stilling basin is designed to dissipate the excess energy of the supercritical flow and provide a reliable control at the downstream end of the channel. The Chaska Creek design has changed from the subcritical design in the limited reevaluation report as a result of a VE study as discussed in another portion of this design memorandum. The level of detail of the hydraulic design is considered more than adequate for this GDM; feature design memorandum hydraulic studies are only anticipated for changes to the design proposed by other disciplines, to determine the need for a debris barrier and to finalize a plan for water control during construction.

DESCRIPTION OF PROJECT

21. Outlet Structure. The outlet structure consists of a parabolic drop into a Saint Anthony Falls type stilling basin with a preformed scour hole downstream. The SAF basin was selected because it performs very well for varying discharges and fluctuating tailwater. Tailwater

elevations were obtained by backwatering from the Minnesota River to the outlet structure. The design tailwater assumes a low pool elevation on the Minnesota River, 688.0, and the creek SPF discharge of 6050 cfs. No degradation of the riprapped outlet channel and tailwater elevation is anticipated. The tailwater and conjugate tailwater elevations are shown on plate A-17. The required tailwater depth used was $0.9d_2$ due to the forces exerted by the baffle blocks and end sill which reduce the required tailwater for a hydraulic jump. This allows a higher bottom elevation which yields a more economical design with improved jump stability during periods of moderately high tailwater.

22. The required top elevation of the training walls (719.0) is equal to the maximum tailwater for which the hydraulic jump will remain in the basin under the SPF flow conditions in Chaska Creek. The top of the wall is set at the conjugate depth of the supercritical flow at the crest of the parabolic drop. The design wall height is about 0.5 foot higher than that obtained by using the recommended freeboard for the minimum tailwater. The recommended freeboard is one-third of d_2. For tailwater depths higher than 719.0, the hydraulic jump will move upstream into the channel. The structural designers have indicated the occurrence of the hydraulic jump in the channel with the resultant differential pressures will not affect the structural design.

23. The location of the outlet structure was set to get a reasonable length of straight approach and avoid the poor foundation soils downstream. It was also attempted to locate the structure far enough from the Minnesota River levee in order to reduce the potential for scour of the levee by creek flows and to increase the stability of the slopes from the top of levee to the bottom of the basin by providing a flat area between the levee and the structure.

24. The preformed scour hole downstream of the stilling basin is designed in accordance with plate C-43 of EM 1110-2-1602. Design data on the outlet structure follows shown on table A-3 follows.

Table A-3

Chaska Creek Diversion Channel Outlet Structure

		Note
Design Discharge	6050 cfs	
Approach Flow Depth	6.56 ft	Normal depth for k = .0024'
Approach Flow Velocity	24.6 fps	
Approach Flow Froude No.	1.69	
Approach Channel Slope	.00604	
Parabolic Drop Eqn	$Y=-(0.00604x+0.02137x^2)$	From eqn 5-3 EM 1110-2-1602
Width	37.5 ft	
Elevation of Crest of Drop	706.0	
Station of Crest of Drop	20+00	
Friction Loss-Parabolic Drop	0	Assumed
Basin Invert	695.0	Computed by trial & error to get a jump
Depth at Bottom of Drop, d_1	4.21 ft	
V_1	38.3 fps	
Fr_1	3.3	
Conjugate Depth, d_2	17.6 ft	
$.9d_2$	15.8	
Required Tailwater	710.8	$.9d_2$+Invert
Available Tailwater	710.5-710.9	
Velocity over End Sill	11.2 fps	
Riprap W_{50} Required Downstream	360 lbs	HDC 712-1 (high turbulence)
Top of Wall Elevation	719.0	
Chute Block Height	4.0 ft.	
Baffle Block Height	4.0 ft.	
End Sill Height	1.5 ft.	
Baffle & Chute Block Spacing	3.0 ft.	
	2.25 ft.	Next to wall
Length of Basin	50.0 ft.	
Distance to Baffle Blocks	17.0 ft.	

Reference: "The SAF Stilling Basin", Agriculture Handbook No. 156, U.S. Department of Agriculture, April 1959.

25. Channel. The proposed channel is designed to flow supercritical. The bottom slope of the channel, .00604 ft/ft, is steep enough to provide Froude numbers above 1.3 as recommended in EM 1110-2-1601 and thus minimize wave heights. The minimum radius for bends was determined from equation 28 of EM 1110-2-1601.

$$r_{min} = \frac{4 V^2 W}{g y}$$

For all bends except the most upstream one, the flow was at normal depth and the minimum radius is about 410 feet. This was determined using velocities and depths using a minimum Chezy k of .0024 foot. For the most upstream curve the flow would not have reached normal depth after coming down the ogee weir and the actual computed velocity and depth through the curve were used to get the minimum radius of 980 feet. The invert of the channel is to be banked at bends. The amount of banking was set equal to twice the superelevation computed by Equation 26 of EM 1110-2-1601.

$$Y = C \frac{V^2 W}{gr}$$

where C = 0.5 since spiral transitions are to be used. The invert of the bottom is rotated about the channel invert grade on the inner side of the curve. The velocity used was computed with average loss coefficients in order to avoid being over or under banked.

26. The channel bottom width changes from 35 feet to 37.5 feet at the ditch inlet at station 37+50. The design SPF discharge changes from 5550 cfs to 6050 cfs. The increased bottom width keeps the normal depth constant.

27. Since the channel is to flow supercritical with high velocities, it is important that the channel be constructed and maintained to have a fairly smooth alignment at the joints with no significant gaps. Because there is the potential for differential settlement, special treatment is needed at the joints. When possible differential settlement of over one inch is computed, the joint must be constructed to eliminate differential setlement. For joints where differentials are less than one inch, the joint must be constructed such that the downstream slab can only end up lower than the upstream slab.

28. Bridges. There are five bridges that cross the proposed channel: the First Street bridge, station 28+95; the Chicago and Northwestern Railroad bridge, station 29+85; the Hickory Street bridge, station 44+60; the Highway 212 bridge, station 56+10; and the Hillside Drive bridge, station 59+70. All bridges are to clear the SPF design water surface profile (high loss) by at least 2.0 feet, have no piers in the channel and do not change the channel width. A table of required low chord elevation follows:

Table A-4

Bridge Data

Bridge	Station	Invert	Design* Water Surface	Banking (ft)	Min** Low Chord
First Street	28+95	711.4	718.6	1.48	722.1
C&NW RR	29+85	711.9	719.1	1.48	722.6
Hickory St.	44+60	720.9	728.1	-	730.1
Hwy 212	56+40	727.8	735.2	1.34	738.3
Hillside Drive	59+70	730.0	736.2	1.20	739.8

* Assume high loss coefficients
** With 2.0 ft. freeboard

29. Inlet Structure. The inlet structure is designed to return water surface profiles to existing conditions upstream of the channel modification, provide a smooth entrance into the supercritical channel and to lower the bottom elevation about 10 feet. The structure includes an ogee crest. The crest shape equations are from plates 24 and 25 of EM 1110-2-1603. The crest shape details are shown on plate A-18. The weir coefficient is from plate 32 of EM 1110-2-1603. ETL 1110-2-158, EM 1110-2-1601 and conversations with Mr. Bernie Johnson, LAD, were also used in the design and layout of the inlet structure. The ogee crest elevation was established to match existing conditions water surface profiles for various flood frequencies upstream of the project. The rating curves are shown on plate A-19. The structure is to be located just downstream of and tied into a natural restriction to help funnel the flow into the channel and prevent flanking.

PRE-POST PROJECT CONDITIONS

30. Existing conditions water surface profiles and flooded outlines were not changed for Chaska Creek from those shown in the limited reevaluation report and outlines have not been replotted. Proposed conditions are to be protected from all floods up to the standard project flood, thus proposed conditions flooded outlines are also not plotted. Proposed conditions flood profiles are shown on plate A-20.

PROTECTIVE MEASURES

31. The Chaska Creek project is designed to eliminate damages from all floods up to the standard project flood. Exceedence of the design capacity during the project economic life has a 28 percent chance of occurring. This is based on a 100-year economic life and the SPF discharge of 5550 cfs having an exceedance probability of 0.33 percent (plate 4A-7 of the limited reevaluation report).

HYDRAULIC LOSSES

32. A sensitivity analysis was performed on the impact of the friction loss factors on stage, velocity and Froude Number. Because the proposed channel is prismatic, expansion and contraction losses are minor and no sensitivity analysis was performed on them. There are no bridge piers or constrictions, therefore, there are no bridge losses. The Chezy equation was used for friction losses with the roughness values for the concrete channel from page 9 of EM 1110-2-1601. The k values shown in the EM for straight channels were increased 20 percent due to the bends. The results of the study are shown below for the design discharges of 5500 cfs from station 64+52 to 37+50 and 6050 cfs from stations 37+50 to 20+00.

Table A-5

Chaska Creek Sensitivity Analysis

	Low Loss	Med Loss	High Loss
Chezy k, (ft.)	.0024	.0054	.0084
Sta 64+52.6 to 37+50			
Normal depth, y_n (ft.)	6.5	6.9	7.2
Velocity at y_n (fps)	24.3	22.9	22.1
Froude No. at y_n	1.7	1.5	1.5
Equivalent Manning's "n"	.0135	.0147	.0155
Sta 37+50 to 20+00			
Normal depth, y_n	6.6	7.0	7.2
Velocity at y_n	24.6	23.2	22.4
Froude No. at y_n	1.7	1.6	1.5
Equivalent Manning's "n"	.0135	.0147	.0155

Bottom width Sta 64+52.6 to 37+50 = 35.0 ft.
Sta 37+50 to 20+00 = 37.5 ft.
Bottom slope = .00604

33. From the above table it is seen that the velocity, depth and Froude numbers are not very sensitive to the loss coefficients. This is expected for a prismatic concrete channel. A Chezy k value of .125 ft. (Manning's n = .022) would be needed to have normal depth equal critical depth with the subsequent possiblity of large waves. This 15 to 50 fold increase in k is very unlikely if the channel is properly maintained.

WATER SURFACE PROFILE STABILITY

34. The water surface profile for the Chaska Creek concrete rectangular channel is expected to be very stable. No degradation of the bottom is possible. The existing channel upstream is fairly stable (see pages 4B-15 and 4B-16 of the limited reevaluation report) and

sediment aggradation should be minor. Because of the very high velocities in the concrete channel, any minor sediment left in the channel after maintenance should be swept away by the flow if vegetation is not allowed to become established.

APPROACH AND EXIT CHANNELS

35. The exit channel from the outlet structure consists of about a 500 foot long riprapped transition channel from the downstream end of the scour hole, station 18+76, to about station 13+76. The bottom width transitions from 75 feet (twice the stilling basin width) at station 18+76 to existing width (about 20 feet) at station 13+76. At this point the flow should have returned to about the same state as for existing conditions with much of the flow in the overbank areas. Thus, the area from station 13+76 to the Minnesota River, station 0+00, should not be affected by the project.

36. The approach to the ogee crest and concrete channel is a riprap trapezoidal channel with 1 horizontal on 3 vertical slopes, a 35 foot bottom width and an invert slope of 0.0005. This channel is about 300 feet long. This reach is through a natural restriction that funnels the flow into the proposed channel. Under natural conditions, this constriction tends to be a control for upstream flood profiles. By locating the proposed inlet control at the same location as an existing control, it was possible to get a good match of the existing conditions rating curve without going to an elaborate compound weir control structure. Therefore, upstream of station 69+00 the proposed conditions profiles for the full range of floods match the existing conditions profiles very well (see plate A-19). The proposed berm and road raise near the Highway 10 bridge upstream of the project is needed for adequate freeboard to prevent flood flows from going down the highway or its ditches and flanking the proposed channel inlet.

OPERATION AND MAINTENANCE

37. The principle maintenance item on Chaska Creek will be keeping the channel clear and in good repair. As stated in paragraph 34, sediment aggradation is expected to be minor. In the limited reevaluation report, page 4B-16, the total annual sediment removal cost for both Chaska and East Creeks was estimated at $2000 (1982 dollars). Since the design flow is supercritical, major deterioration of the channel could result in a shift to subcritical flow and a large jump in water surface stage. Therefore, it will be especially important to provide good maintenance to Chaska Creek. It will also be very important that no obstructions be placed in the channel in the future, such as bridge piers.

FREEBOARD

38. The proposed channel design for Chaska Creek uses a minimum freeboard for the top of wall of 2.0 feet above the high loss water

surface profile. The use of freeboard is necessary because of the high design velocities and potential project-induced erosion damages if the channel is overtopped. Since the water surface profile is highly stable (see paragraph 15) and since high loss coefficients were used, 2.0 feet of freeboard is considered adequate.

39. Debris and trash from upstream sources is not expected to be a major problem, however, the need for a debris barrier at the upstream end of the project will be examined in detail in the feature design memorandum hydraulic studies.

CARE OF WATER DURING CONSTRUCTION

40. A detailed plan for care of Chaska Creek water during construction has not been developed. Because of the flashy nature of the creek, it will be necessary to develop a fairly detailed plan for the feature design memorandum.

SIDE DRAINAGE

41. There will be two side drainage inlets, one from the right at about station 37+50 and one from the left near First Street. The drainage from the left contributes a peak design discharge (SPF) of 690 cfs. The hydraulic design for the proposed channel that will convey the flood waters into the proposed Chaska Creek diversion channel will include a control structure, a tranquil flow channel, an ogee crest inlet to a rapid flow channel, a rapid flow channel and a side inlet.

42. Control Structure. The drop structure located on the downstream side of the service road south of Mndot Highway 212 has a crest elevation of approximately 738 (the upstream invert elevation should match the existing invert elevation). The downstream bottom elevation is 726.6. Other dimensions for the control structure are length 35 feet, width 9 feet, elevation-floor of structure 724.1.

43. Tranquil Flow Channel. The proposed tranquil flow rectangular channel is designed to convey the design discharge from the control structure through a bend to the ogee weir. The bottom slope is .001 foot/foot, bottom width 9 feet and design depth 7.7 feet plus 2 feet of freeboard and design velocity 10 fps.

44. Ogee Crest. An ogee weir is located 50 feet downstream of the downstream end of the curve in the tranquil flow channel described above. The purpose of this structure is to maintain tranquil flow upstream of the crest and to provide a smooth transition from tranquil to rapid flow. The crest coefficient (3.85) and shape are from EM 1110-2-1603.

45. Rapid Flow Channel. The rapid flow channel from the ogee crest to the side inlet is 9 feet wide with a bottom slope of 0.01 foot/foot. This width and slope were selected to give a Froude number safely above

1.0 for an n value of .014; to keep the velocity on the order of that in the creek; and to keep a reasonable depth of flow (4.2 ft) at the creek inlet. The design depth is 4.2 feet plus 2 feet of freeboard results in a minimum wall height of 6.2 feet. The channel ends in a side channel inlet. The Froude number and velocity in the supercritical reach are 1.6 and 18.3 fps.

46. Side Channel Spillway Inlet. The rapid flow channel empties into the proposed Chaska Creek diversion channel through a side channel spillway inlet. Reference plate 53 of EM 1110-2-1601. The spillway is 120 feet long and the spillway crest is set 0.5 feet above the high loss design water surface in the creek, thus the crest is 7.7 feet above the bottom. The head over the spillway is kept constant by converging the side channel width from 9 feet to 0 feet in the 120 feet. This insures the velocity and depth in the side channel remains constant at 18.3 fps and 4.2 feet. A 12-inch drain is provided at the low point of the side channel. The proposed Chaska Creek diversion channel bottom width will increase from 35 feet at the upstream end of the inlet to 37.5 feet at the downstream end.

47. The inlet into the left side of the channel near First Street is required for interior flood control and the design of this inlet is described in the interior flood control appendix. The inlet consists of a 60 inch diameter RCP entering the creek at a 30 degree angle. This angle was selected to be in conformance with EM 1110-2-1601, page 62, paragraph 18.h. There is a flap gate upstream of where the pipe inlets into the creek and this inlet should not be contributing when the creek discharge is high.

HYDRAULIC DESIGN
EAST CREEK

GENERAL

48. The proposed East Creek diversion channel is a combination of features designed to provide protection from the standard project flood. These include from the upstream end of the proposed project an inlet control structure; a 0.12-mile long concrete rectangular channel; a cylindrical quadrant transition; a 0.17-mile long riprap trapezoidal channel; a 0.87-mile long levee; a diversion conduit consisting of an inlet structure; a 0.28-mile long conduit and an outlet stilling basin; a 0.3-mile long grass lined channel and a control structure. The design flood discharge is 6,220 cfs. The proposed alignment and features have changed from those shown in the limited reevaluation report. The alignment proposed in this report will follow approximately the same alignment as alternative 4 shown on page 2-4 of the limited reevaluation report. The inlet control structure is designed to raise the lowered water surface elevations and channel bottom in the project area to match the pre-project existing conditions water surfaces and thalweg upstream of the project. The rectangular concrete channel is required because of the narrow passage between the

trailer park and the high bluff. The rectangular concrete channel and riprap trapezoidal channel are designed to lower the design water surface profile and prevent overtopping of Engler Boulevard. The levee in the reach from Engler Boulevard to the Crosstown Boulevard is designed to protect the areas south and downstream of East Creek. The diversion conduit is designed to divert the flood waters from the East Creek channel at Crosstown Boulevard. The grass lined trapezoidal channel is designed to convey the flood waters from the diversion conduit through the Minnesota River floodplain. The control structure is designed to maintain the water surface profile in the grass lined channel and to dissipate the excess energy where the diversion channel reenters the existing East Creek channel. With respect to the major changes proposed for the East Creek diversion channel, the level of detail of this hydraulic design is considered adequate for this report. Feature design memorandum hydraulic studies are anticipated to refine the hydrauic design presented here and to reflect the refinements proposed by other disciplines. Items to be studied would include:

- Increasing the amount of water diverted into the existing channel at the Crosstown Boulevard

- Review of the types and location of features to optimize cost effectiveness

- Determine the need for a debris barrier

- Finalize a plan for water control during construction

- Examine the possibility of reducing the peak of the design flood by modifying the proposed Highway 41 bridge

- Changes to the hydraulic design as a result of refinements from the feature design memo

- Further refinement of the hydraulic design if the hydrology changes as a result of feature design hydrology studies

Specific design considerations for updating the hydraulic design in the feature design memo are described in the following sections in more detail.

DESCRIPTION OF PROJECT

Inlet Control Structure

49. The inlet structure is designed to return water surface profiles to existing conditions upstream of the channel modification, and lower the bottom elevation 17 feet. The structure is designed from plate 43 of EM 1110-2-1601. The weir crest elevation was established to match existing conditions water surface profiles for a variety of flood frequencies upstream of the project. The rating curves are shown on

plate A-21. This structure will be located just downstream of a natural restriction to help funnel the flow into the channel and prevent flanking.

Channel

50. The proposed channel upstream of the Crosstown Boulevard is divided into three reaches here for hydraulic purposes. They are: a) a rectangular concrete channel and transition; b) a riprap trapezoidal channel; and c) natural channel.

Rectangular Channel

51. The reach from the upstream end of the project inlet control structure to Brandon Boulevard is a 0.12-mile long, 50-foot wide concrete rectangular channel with 14.5-foot side walls. This selection was made for two reasons: 1) physical constraints - The configuration of the channel between the residents on the left bank and the high bluff on the right bank limits the cross section area; and 2) the left channel bank is low, and overtopping will occur if a flood of the magnitude of the design discharge occurred. Other configurations were considered such as a riprap trapezoidal channel and levees with no channel modification, but insufficient area is available for these alternatives. The bottom slope is mild enough to provide Froude numbers adequately below 0.86 to insure tranquil flow for this reach. The minimum bend radius at the downstream end of this reach is 150 feet (see paragraph 11.c.(1) of EM 1110-2-1601). The invert of the channel is banked at bends. The amount of banking was set equal to twice the superelevation computed by equation 26 of EM 1110-2-1601.

$$Y = C \frac{V^2 W}{gr}$$

where C = 0.5 since spiral transitions are to be used. The invert of the bottom is rotated about the channel invert grade on the inner side of the curve. The roughness coefficient of 0.014 (Manning's "n") was used in these design computations. Further analysis of this reach will be performed in the feature design memorandum which will include refinement of channel dimensions, type of channel and sensitivity analysis. The downstream end of the rectangular channel consists of a 160-foot cylindrical quandrant transition from the 50-foot rectangular channel to a riprap trapezoidal channel described in the next section. The transition dimensions were determined from plate 19 in EM 1110-2-1601, otherwise known as the hydraulic engineers Bible.

Riprap Channel

52. The reach from the downstream end of the transition at Brandon Boulevard to Engler Boulevard is a riprap trapezoidal channel with 70-foot bottom width. This design is necessary because the flow area in

this reach is constricted and to prevent overtopping of Engler Boulevard. If Engler Boulevard is overtopped, flooding will occur behind the East Creek levee system. The roughness coefficient used for computations in this reach is 0.035. The design of this reach will be refined in the feature design memorandum. This will include channel dimensions and sensitivity analysis.

Natural Channel

53. The reach from Engler Boulevard to the Crosstown Highway will consist of the natural channel. This reach is a park and green belt area which the city does not want disturbed, so the natural channel and wide floodplain will be used to convey the water to the diversion conduit. The residential area south of the parkway will be protected by a levee as described in paragraph 54 below. This reach will require additional analysis in the feature design memorandum hydraulic studies to determine the sensitivity of the design water surface profile.

East Creek Levee

54. A levee is proposed for the reach from Engler Boulevard to Crosstown Boulevard. The levee alignment will be along the south bank of East Creek from Engler Boulevard to Crosstown Highway, then north parallel to the Crosstown Boulevard. The purpose of the proposed levee is to protect the area south and downstream of East Creek and to leave the park area in this reach undisturbed. This alternative was selected because the city wishes to keep this area as a park and it is more cost effective to construct a levee than it is to provide channel modifications. The overbank area to the north of the existing channel is flat and wide, providing sufficient capacity to convey the design flood from Engler Boulevard to the conduit inlet structure. However, flood storage capacity in this area was determined to be too small to attenuate the flood peaks into the diversion conduit.

Low Flow Conduit

55. A 48-inch RCP conduit with closure gate will be placed in the alignment of the existing East Creek channel just upstream of the Crosstown Highway. The purpose of this conduit will be to allow low flows to continue in the existing channel downstream of the diversion. A closure structure will be included so that discharge through the conduit can be stopped during times of Minnesota River flooding. Further refinement of this alternative to be considered in the feature design memo hydraulic studies will consist of determining the maximum flow that could be allowed through the low flow conduit. Increasing the discharge through the low flow conduit would decrease the peak discharge to be diverted into the diversion conduit described in the following paragraphs. Any flood waters diverted through the low flow conduit would be stored in the Courthouse Lake interior flood control pond (see Interior Flood Control appendix).

Diversion Conduit Works

56. The proposed conduit works will divert flows up to the design flood from the East Creek channel just upstream of Crosstown Highway to a grass lined channel in the Minnesota River Valley. This location was selected because there is access through the residential area from the creek to the Minnesota River Valley. The three components of the East Creek diversion conduit works are an inlet structure, a cut and cover conduit and a chute spillway.

Inlet Structure

57. The inlet structure design presented here has been updated from the limited reevaluation report. The drop inlet design is a box inlet drop spillway. This design is adapted from SCS TP-106 "Hydraulic Design of the Box Inlet Drop Spillway", figure 24. The elbow design was developed using the equation shown below for flared entrances from paragraph 3-6-c of EM 1110-2-1602. The side and top flare equation for the proposed elbow is:

$$\frac{X^2}{D^2} + \frac{Y^2}{(D/3)^2} = 1 \qquad \text{where } D = 16$$

When computing the headwater elevation, the tailwater for the inlet control structure was assumed equal to the computed headwater energy grade line for the conduit.

Conduit

58. The proposed 16-foot box culvert is 1,500 feet long, with an inlet invert elevation of 717.0 and an outlet invert elevation of 709.24. The head loss was computed using the following equation:

Outlet Control from figure B-11, TM 5-820-4

$$H = \left[\frac{1.555\ (1+K_e)}{D^4} + \frac{287.64\ n^2\ L}{D^{16/3}}\right] \left[\frac{Q}{10}\right]^2$$

$$K_e = \frac{1}{C^2} - 1 \qquad \text{Page 472 Design of Small Dams}$$

$n = 0.014 \qquad D = 16'$

$C = 0.95$

Inlet Control - Page 472 Design of Small Dams

$$H = \frac{1}{C^2} \frac{V^2}{2g}$$

$C = 0.95$

Chute Spillway

59. The proposed transition from the conduit to the open channel is an energy dissipator (presented in chapter 5 of EM 1110-2-1602) designed to prevent downstream channel degradation. The Corps program H2261 was used to design the structure. The design includes a transition with a sidewall flare of 1 on 6 and a bottom parabolic curve to the hydraulic jump and a rectangular cross section stilling basin. The energy dissipator is 165 feet long, expands from 16 feet to 33.6 feet wide at the bottom, and has a drop of 13.2 feet. The chute spillway empties into a 48-foot wide riprap outlet channel as shown on plate C-42 of EM 1110-2-1602. Feature design memorandum hydraulic studies of the chute and stilling basin will include a sensitivity analysis.

Grass Lined Channel

60. The proposed channel from the diversion conduit to the existing East Creek channel is a 0.28-mile long grass lined channel with 94 feet bottom width and 3H on 1V side slopes. The invert of the channel at elevation 700, NVGD of 1929, is far enough above the normal low pool elevation 688, NVGD of 1929, on the Minnesota River so that vegetation can easily be established. The design water surface elevation 715, NVGD of 1929, is also the 10-percent chance flood water surface elevation on the Minnesota River. This is the maximum coincident flood elevation anticipated on the Minnesota River during a design flood on East Creek.

Control Structure

61. The proposed grass lined channel will terminate at a California Institute of Technology-type control structure (see plate 43, EM 1110-2-1601). The purpose of this control structure is to maintain the water surface profile in the grass lined channel and to dissipate the excess energy as the flood flows reenter the existing East Creek channel at approximately station 5+00. To determine the maximum excess design energy for the stilling basin, the normal low pool elevation on the Minnesota River was assumed.

Bridges

62. There are two bridges that cross the proposed channel. These are at Brandon Boulevard station 83+00 and Engler Boulevard station 74+00. All bridges are to clear the SPF design water surface profile by at least 3.0 feet. Neither bridge has piers. The bridge at Engler Boulevard will change the channel from trapezoidal to rectangular. No channel configuration change is proposed at Brandon Boulevard.

Pre-Post Project Conditions

63. Existing conditions water surface profiles and flooded outlines for East Creek are the same as those shown in the limited reevaluation report. The outlines have not been replotted. Proposed conditions have changed. Because of the revision in alignment, flooding will occur in the park area between Engler Boulevard and the Crosstown Highway. The flooded area outline for this area will be developed in the feature design hydraulic studies. Proposed conditions design water surface profiles are shown on plate A-22.

64. Sufficient tributary area is available on the existing East Creek channel downstream of the proposed diversion channel to generate minor flooding as discussed in the limited reevaluation report. Because the diversion channel has been relocated downstream from the previous report, the magnitude of this flooding should be reduced. The residual floodplain for East Creek was analyzed with the East Creek HEC-2 model (refer to the paragraph on East Creek without project conditions water surface profiles in the limited reevaluation report) and the interior flood control runoff hydrographs presented in appendix B. The results of this analysis are shown on plates A-23 and A-24.

Protective Measures

65. The East Creek project is designed to eliminate damages from all floods up to the standard project flood. Exceedance of the design capacity during the project economic life has a 4.9 percent chance of occuring. This is dependent on a 100 year economic life and the SPF discharge of 6200 cfs having an exceedance probability of 0.05 percent.

Hydraulic Losses

66. A sensitivity analysis of the appropriate components will be performed in the feature design memorandum hydraulic studies. No major changes of the proposed components are anticipated as a result of the sensitivity analysis.

Water Surface Profile Stability

67. The water surface profile stability will be analyzed in the feature design memorandum hydraulic studies.

Approach and Exit Channel

68. The approach to the inlet control structure consists of the natural channel. The inlet control structure is designed to return the water surface profiles to pre-project conditions. The necessity to provide a short approach channel will be reviewed in the feature design hydraulic studies.

69. The exit channel from the control structure at station 5+00 consists of the existing East Creek channel. The exact configuration or shaping necessary in this reach will be determined in the feature design hydraulic studies.

Operation and Maintenance

70. The principle maintenance item on East Creek will be keeping the channel clear and in good repair. Sediment aggradation is expected to be minor. In the limited reevaluation report, page 4B-16, the total annual sediment removal cost for both Chaska and East Creeks was estimated at $2000 (1982 dollars). This topic will be reviewed in the feature design hydraulic studies after the East Creek plan has been refined. Items for review will include degradation of the channel from Brandon to Engler Boulevards and aggradation of the conduit and grass lined channel.

Freeboard

71. The proposed channel design for East Creek uses a minimum freeboard of 2 feet for rectangular concrete channels, 2.5 feet for trapezoidal channels and 3 feet for earth levees. Freeboard is provided to ensure that the desired degree of protection will not be reduced by unaccounted factors. Stability of the channel and various loss coefficients will be developed in the feature design memo hydraulic studies.

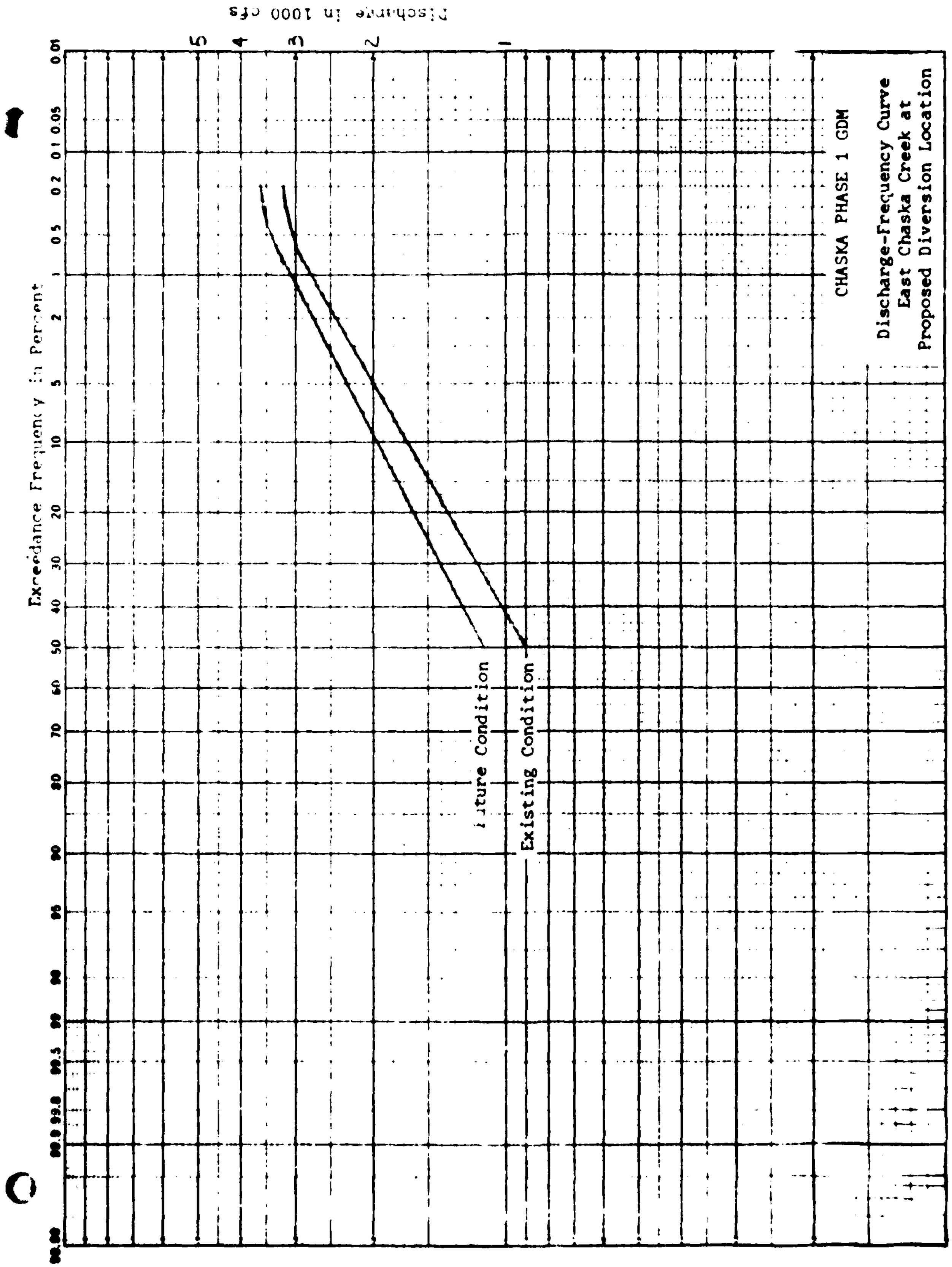
72. Debris and trash from upstream sources is not expected to be a major problem, however, the need for a debris barrier at the upstream end of the project will be examined in detail in the feature design memorandum studies.

Care of Water During Construction

73. A detailed plan for care of East Creek water during construction has not been developed. Because of the flashy nature of the creek, it will be necessary to develop a fairly detailed plan for the feature design memorandum.

Low Flow Channel

74. The existing creek channel downstream of Engler Boulevard will provide the low flow channel. The 48 inch diameter low flow conduit will allow up to a maximum of 80 cfs to be diverted into the existing channel. Provisions for a low flow channel from the upstream end of the project to Engler Boulevard will be developed in the feature design memo hydraulic studies.



CHASKA PHASE 1 GDM
Discharge-Frequency Curve
East Chaska Creek at
Proposed Diversion Location
Discharge in 1000 cfs
5
4
3
2
1
Exceedance Frequency in Percent
0.01
0.05
0.1
0.2
0.5
1
2
5
10
20
30
40
50
60
70
80
90
95
98
99
99.5
99.8
99.9
99.99
uture Condition
Existing Condition

PLATE A-1

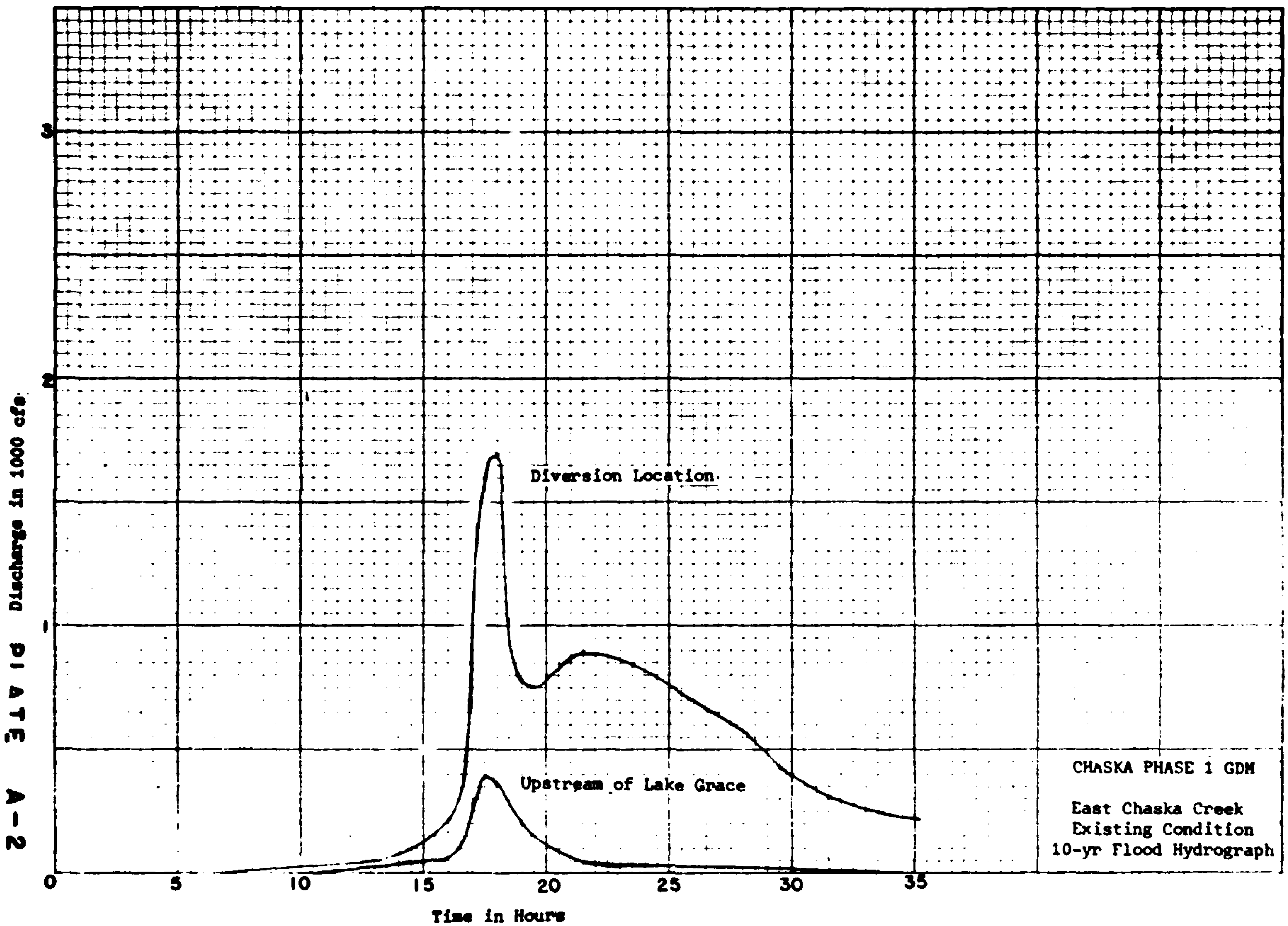

Discharge in 1000 cfs
3
2
1
0
5
10
15
20
25
30
35
Time in Hours
Diversion Location
Upstream of Lake Grace
CHASKA PHASE 1 GDM
East Chaska Creek
Existing Condition
10-yr Flood Hydrograph

PLATE A-2

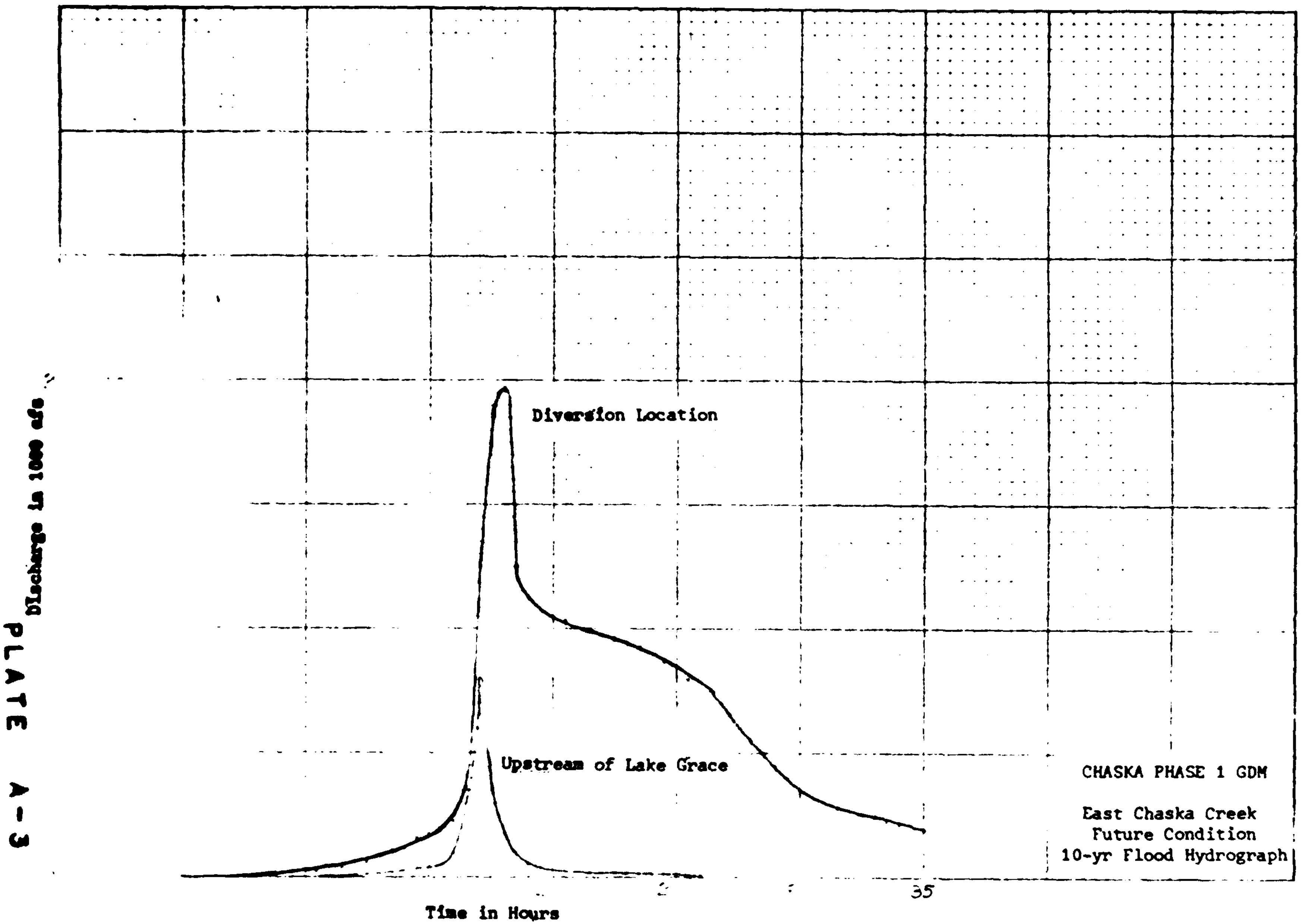

Diversion Location
Upstream of Lake Grace
CHASKA PHASE 1 GDM
East Chaska Creek
Future Condition
10-yr Flood Hydrograph
35
Time in Hours
Discharge in 1000 cfs

PLATE A-3

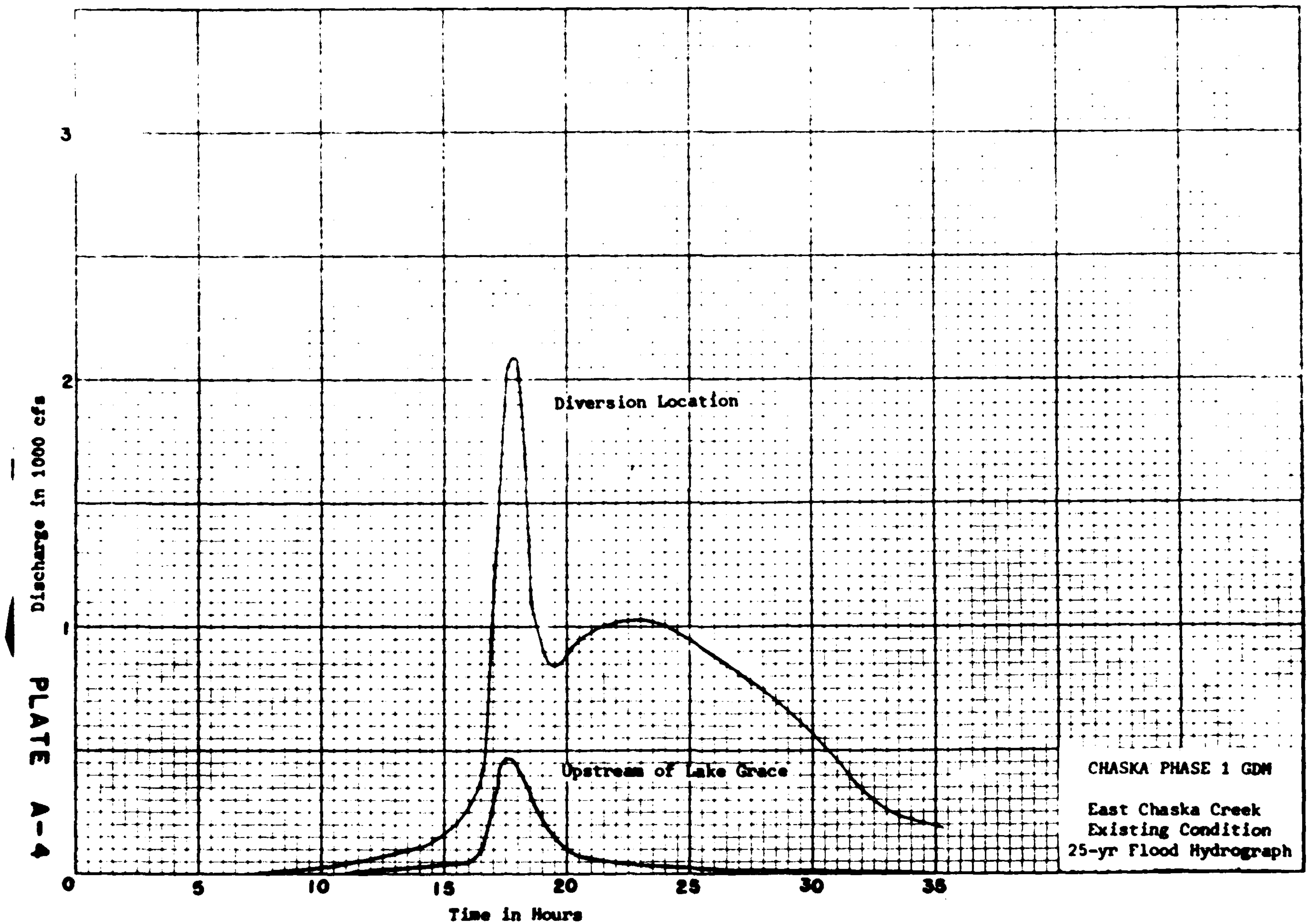

CHASKA PHASE 1 GDM
East Chaska Creek
Existing Condition
25-yr Flood Hydrograph
Diversion Location
Upstream of Lake Grace
Discharge in 1000 cfs
Time in Hours
0
1
2
3
5
10
15
20
25
30
35

PLATE A-4

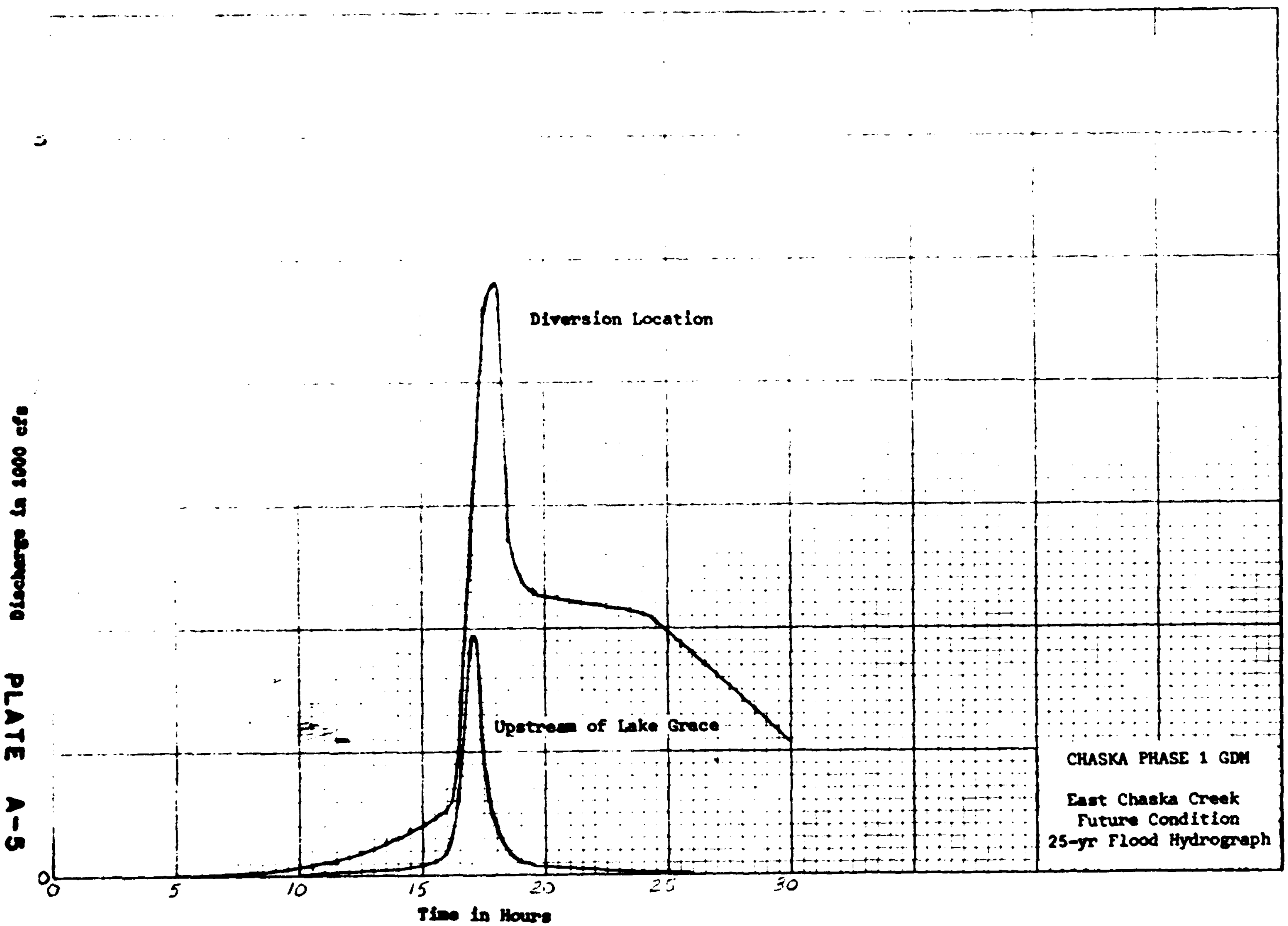

Diversion Location
Upstream of Lake Grace
CHASKA PHASE 1 GDM
East Chaska Creek
Future Condition
25-yr Flood Hydrograph
0
0
5
10
15
20
25
30
Time in Hours
Discharge in 1000 cfs

PLATE A-5

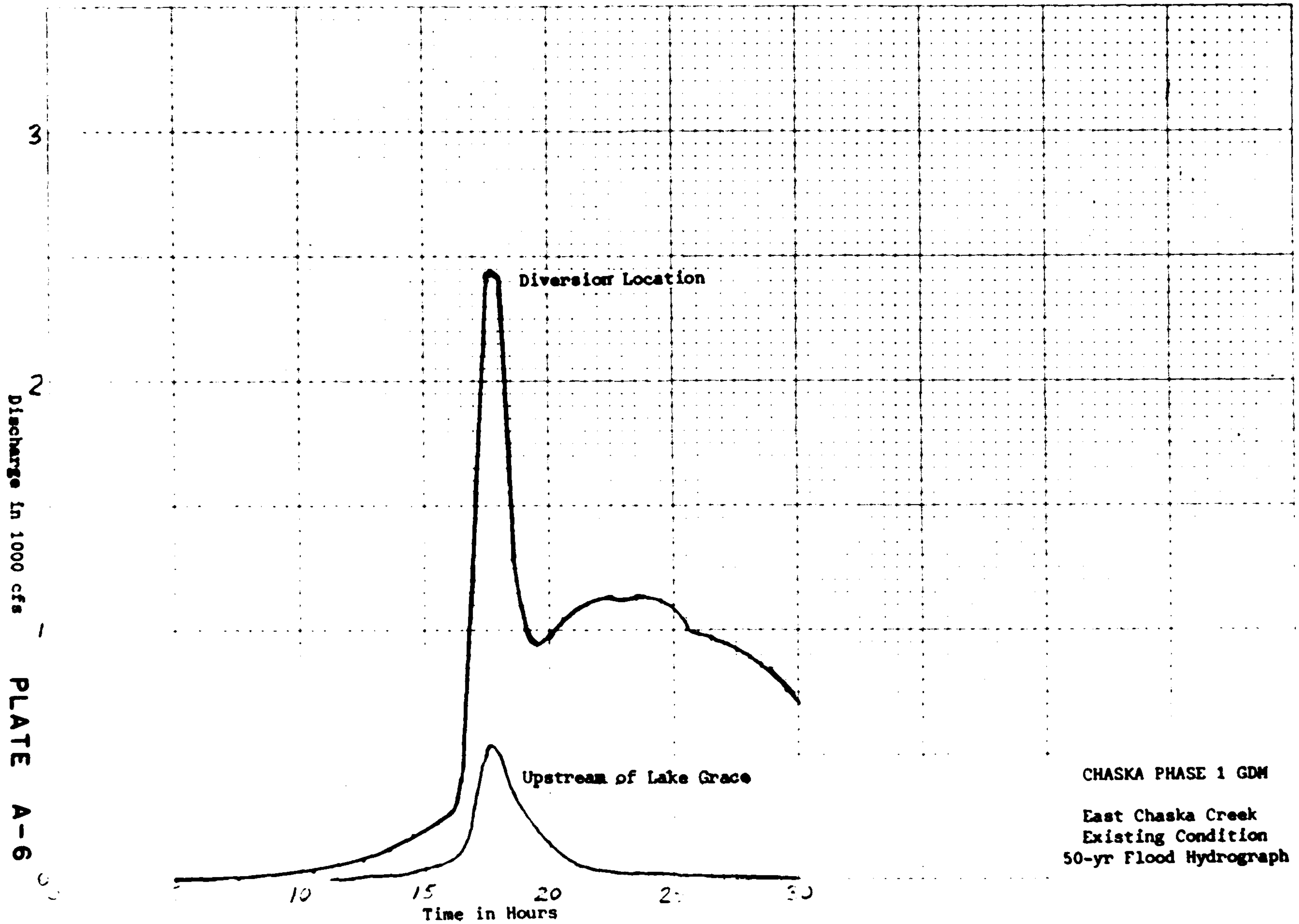
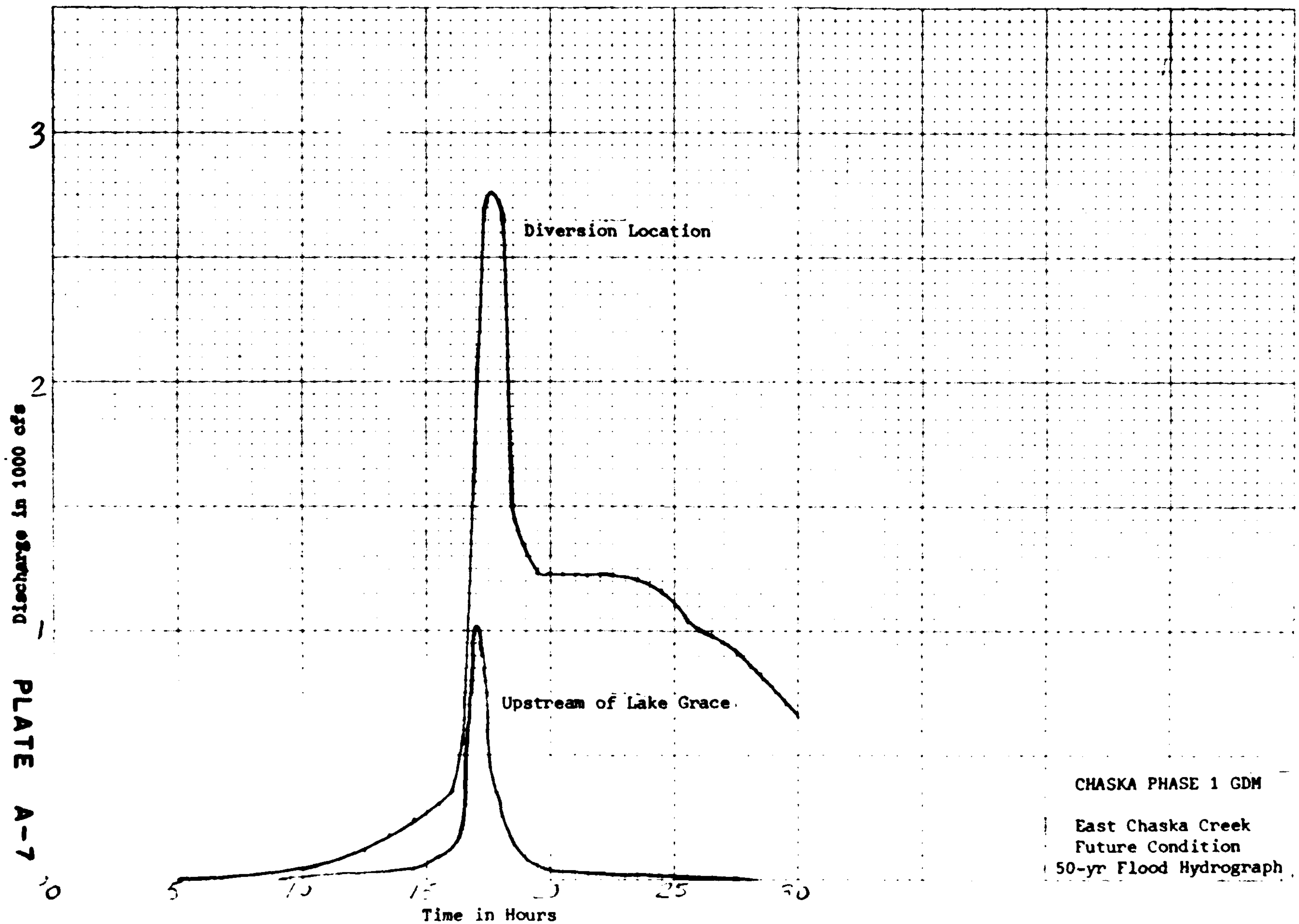

CHASKA PHASE 1 GDM
East Chaska Creek
Existing Condition
50-yr Flood Hydrograph
Diversion Location
Upstream of Lake Grace
3
2
1
10
15
20
Time in Hours
Discharge in 1000 cfs

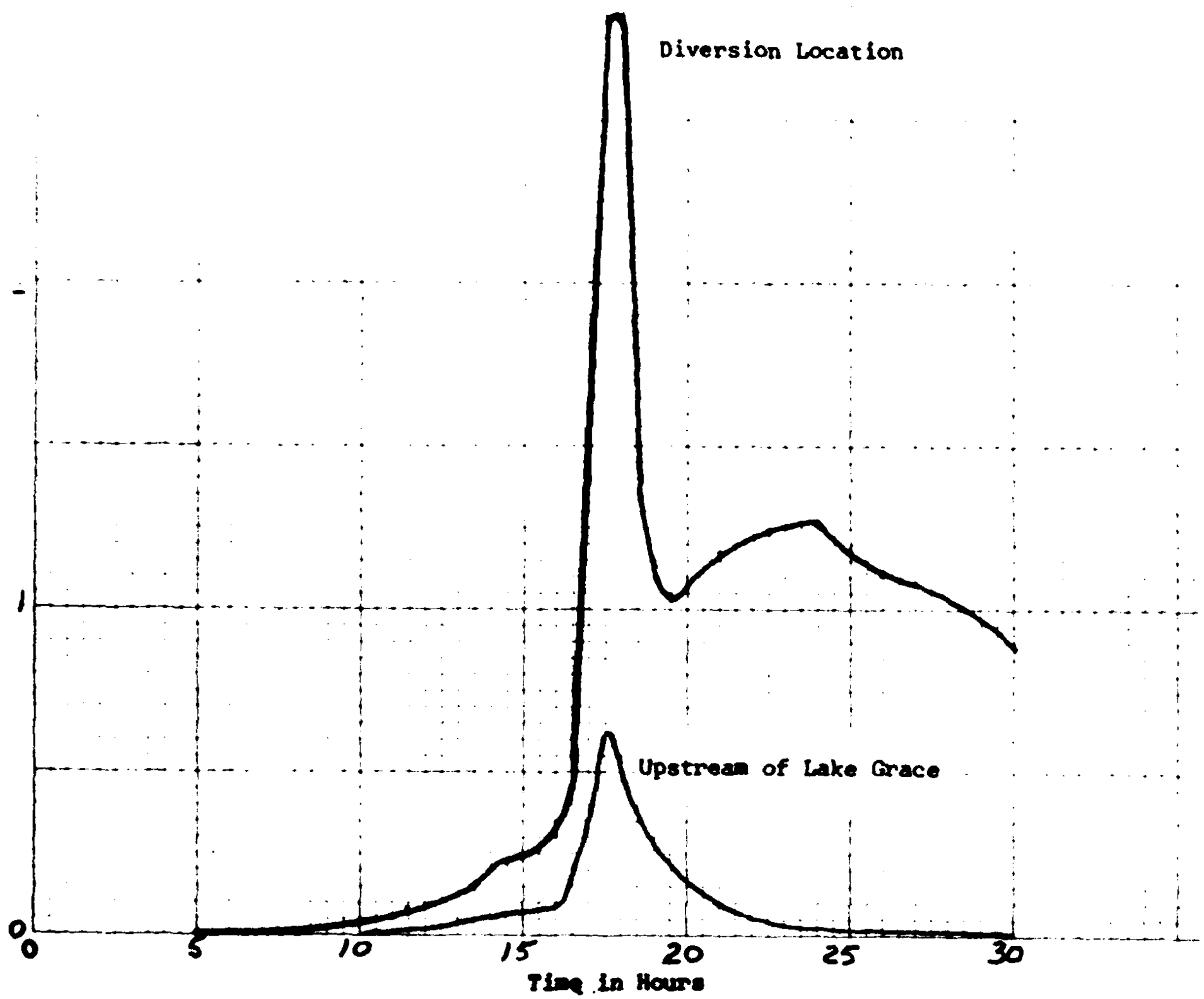
PLATE A-6



CHASKA PHASE 1 GDM

East Chaska Creek
Future Condition
50-yr Flood Hydrograph

PLATE A-7



CHASKA PHASE 1 GDM

East Chaska Creek
Existing Condition
100-yr Flood Hydrograph

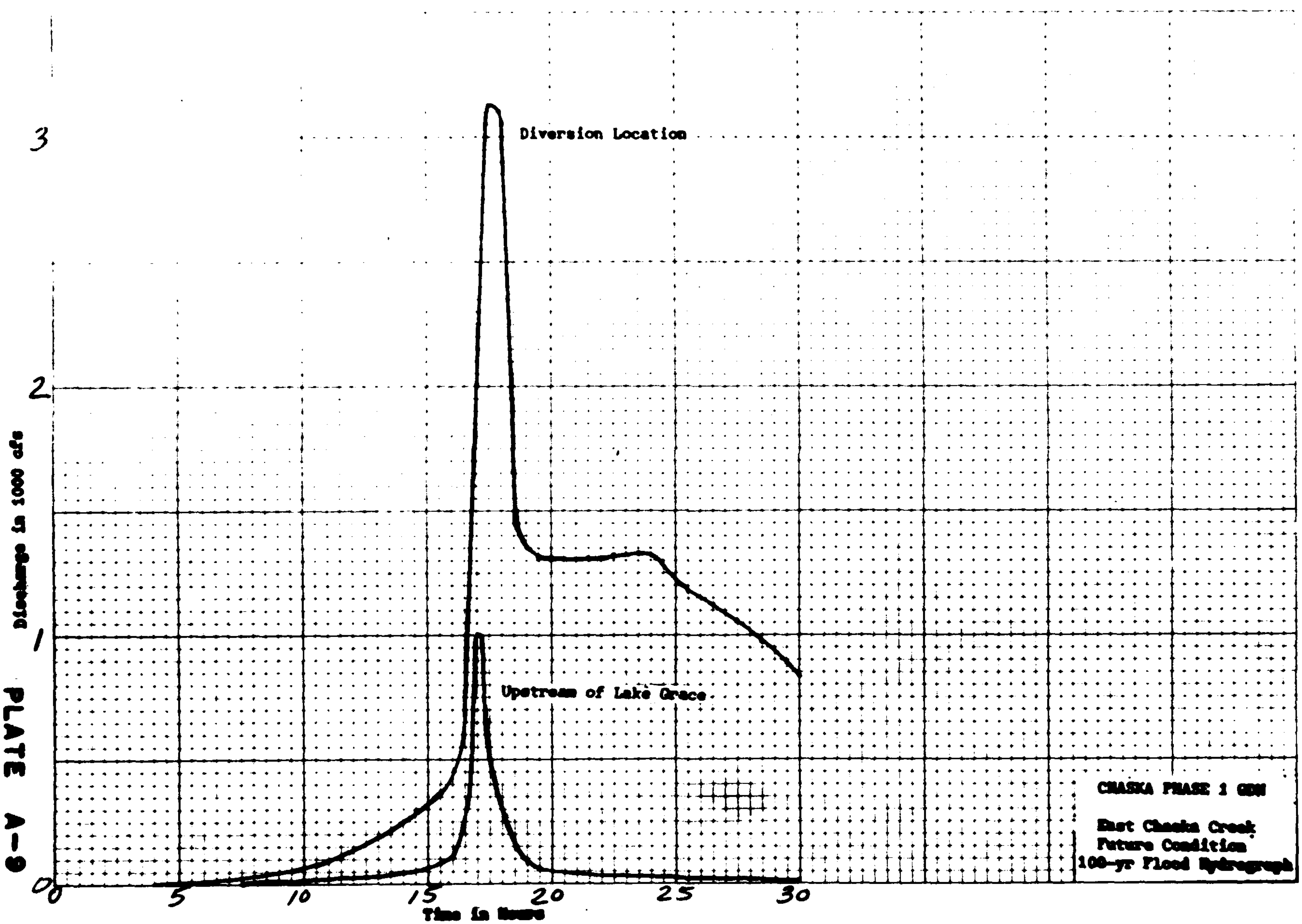
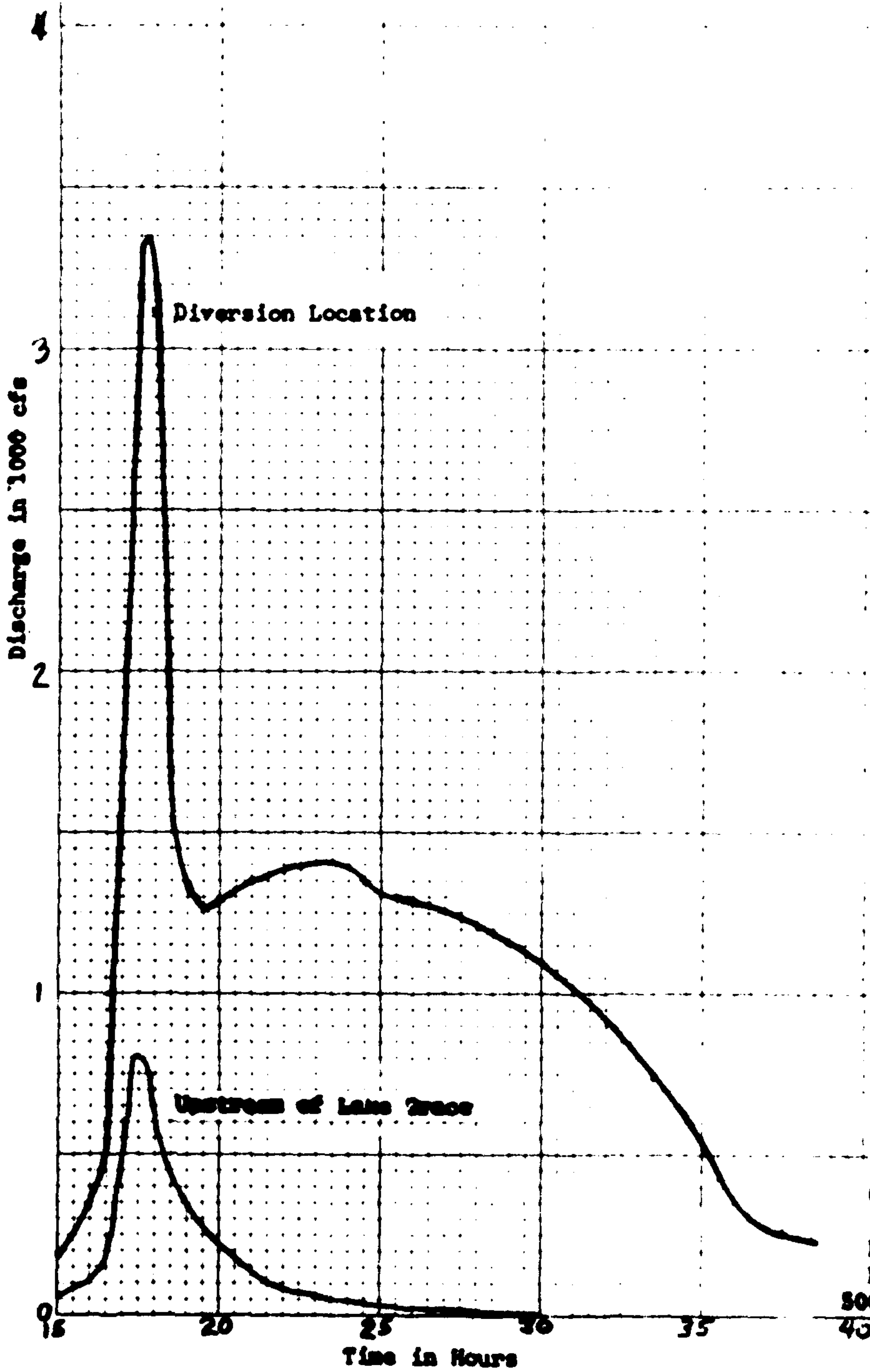

Diversion Location
Upstream of Lake Grace
Discharge in 1000 cfs
Time in Hours
0
1
2
3
0
5
10
15
20
25
30
CHASKA PHASE 1 GDM
East Chaska Creek
Future Condition
100-yr Flood Hydrograph

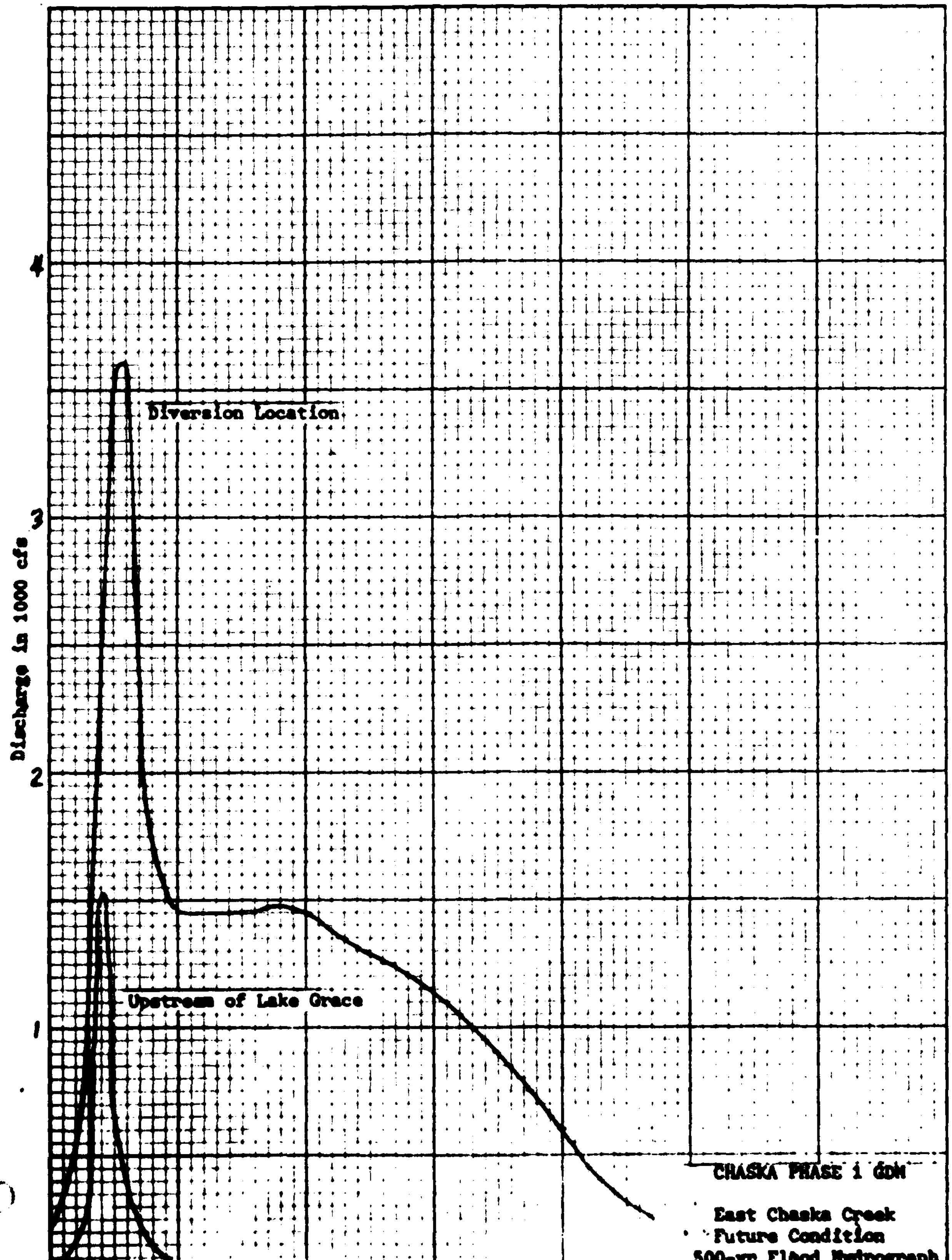
PLATE A-9



CHASKA PHASE 1 GDM

East Chaska Creek
Existing Condition
500-yr Flood Hydrograph

PLATE A-10



Diversion Location
Upstream of Lake Grace
Discharge in 1000 cfs
4
3
2
1
0
15
20
25
30
35
40
Time in Hours
CHASKA PHASE I GDM
East Chaska Creek
Future Condition
500-yr Flood Hydrograph

PLATE A-11

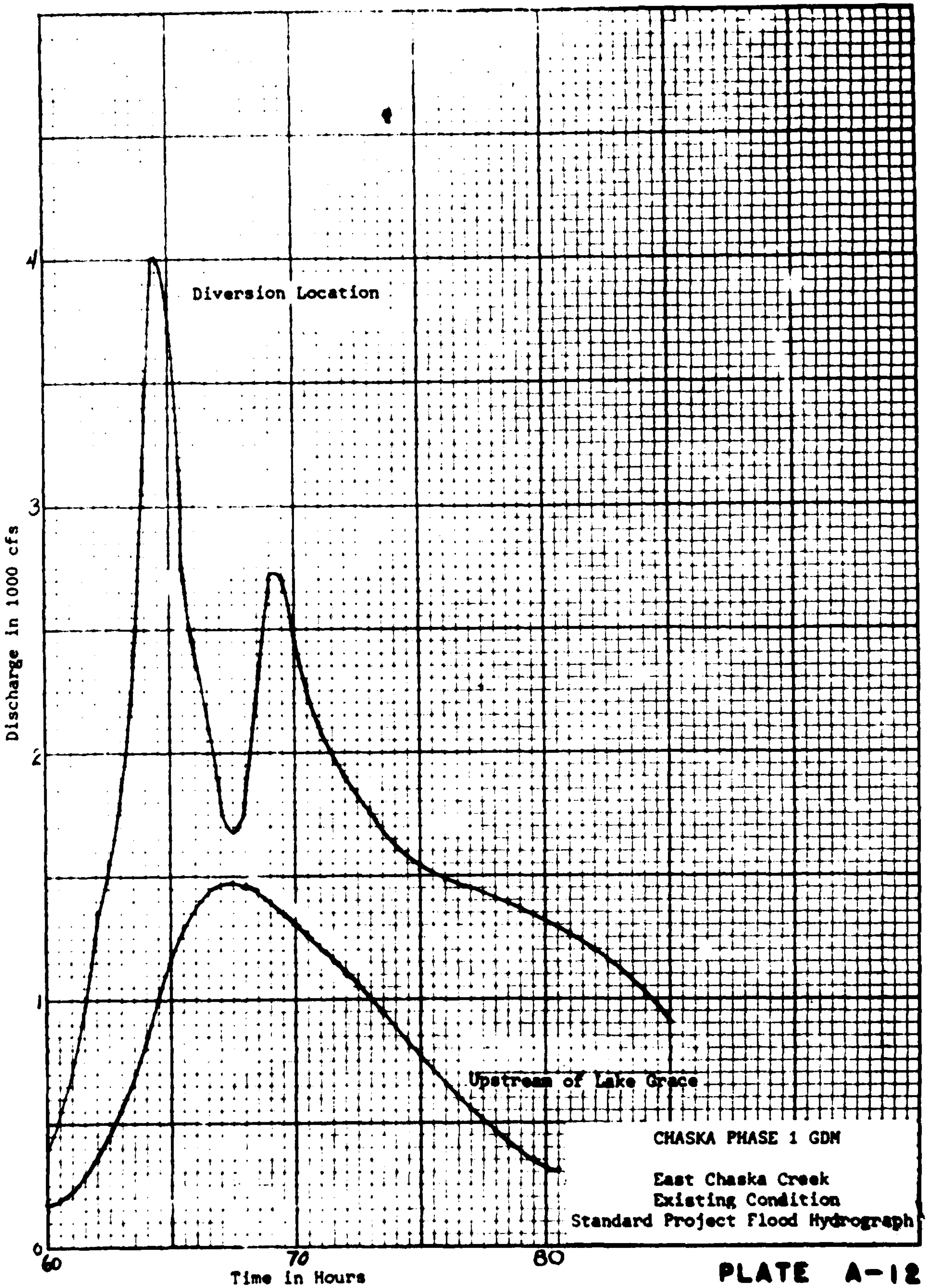
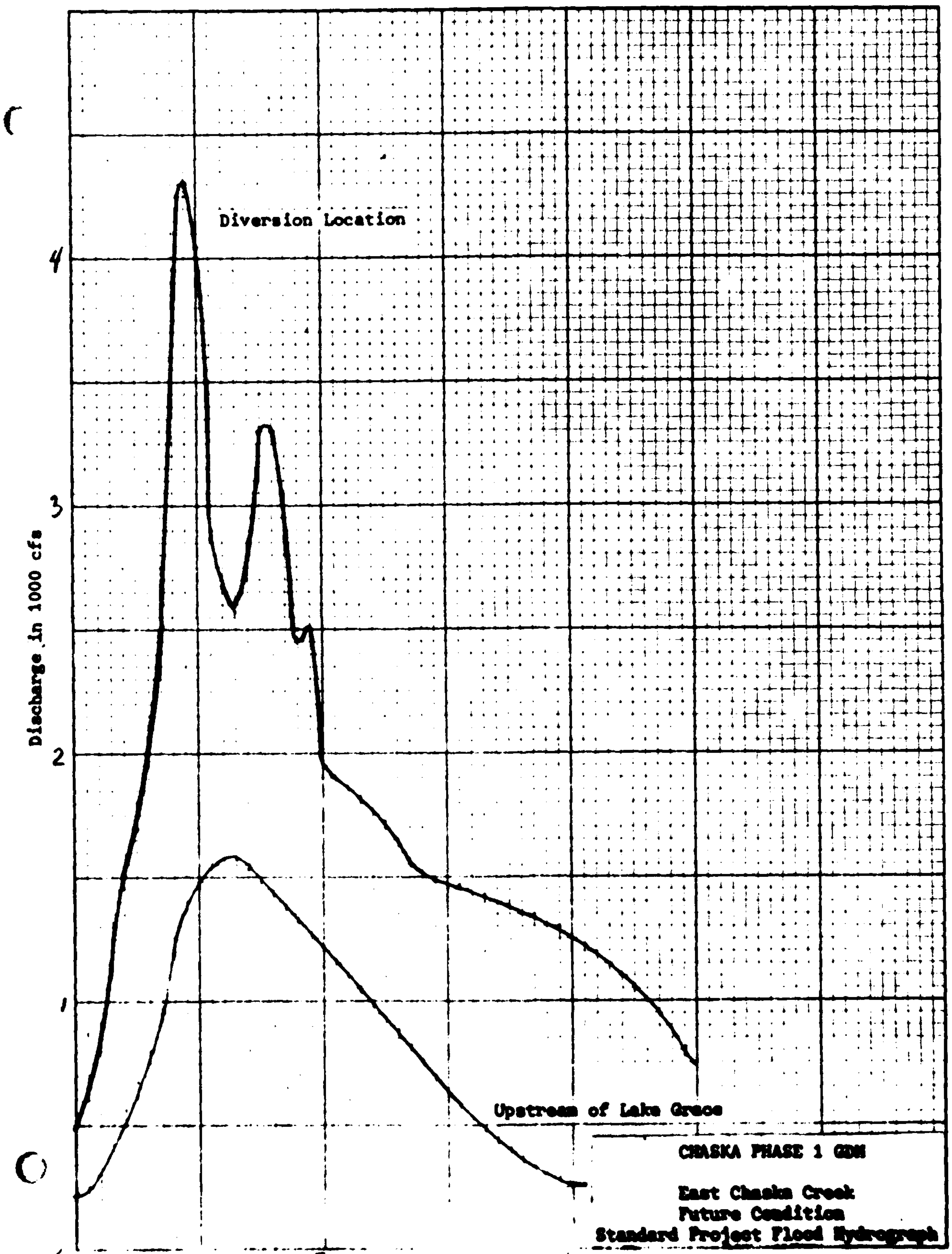

Diversion Location
Upstream of Lake Grace
Discharge in 1000 cfs
0
1
2
3
4
60
70
80
Time in Hours
CHASKA PHASE 1 GDM
East Chaska Creek
Existing Condition
Standard Project Flood Hydrograph

PLATE A-12



Diversion Location
Upstream of Lake Grace
Discharge in 1000 cfs
4
3
2
1
Time in Hours
70
CHASKA PHASE 1 GDM
East Chaska Creek
Future Condition
Standard Project Flood Hydrograph

PLATE A-13

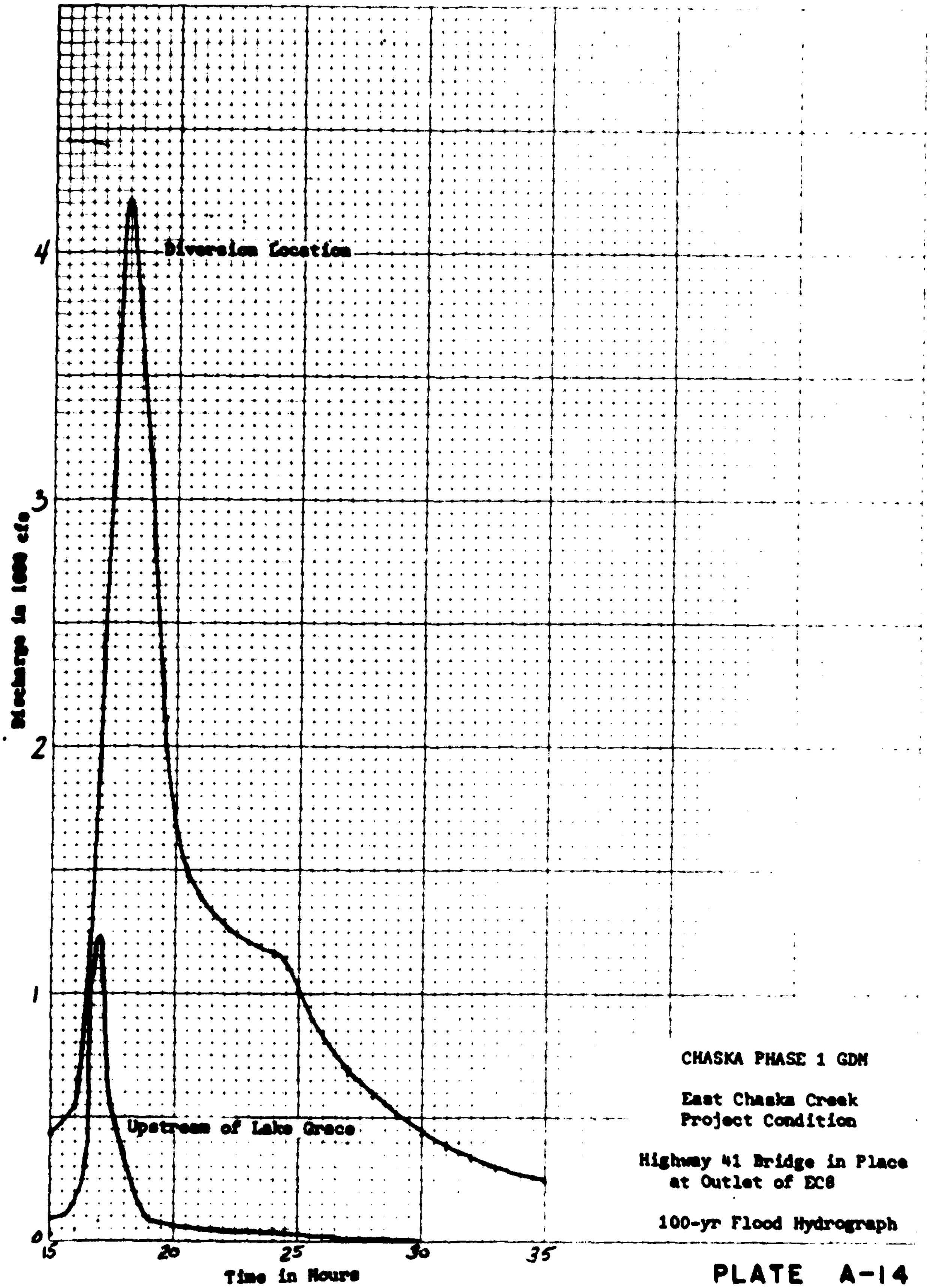

Diversion Location
Upstream of Lake Grace
Discharge in 1000 cfs
Time in Hours
0
1
2
3
4
15
20
25
30
35
CHASKA PHASE 1 GDM
East Chaska Creek
Project Condition
Highway 41 Bridge in Place
at Outlet of EC8
100-yr Flood Hydrograph

PLATE A-14

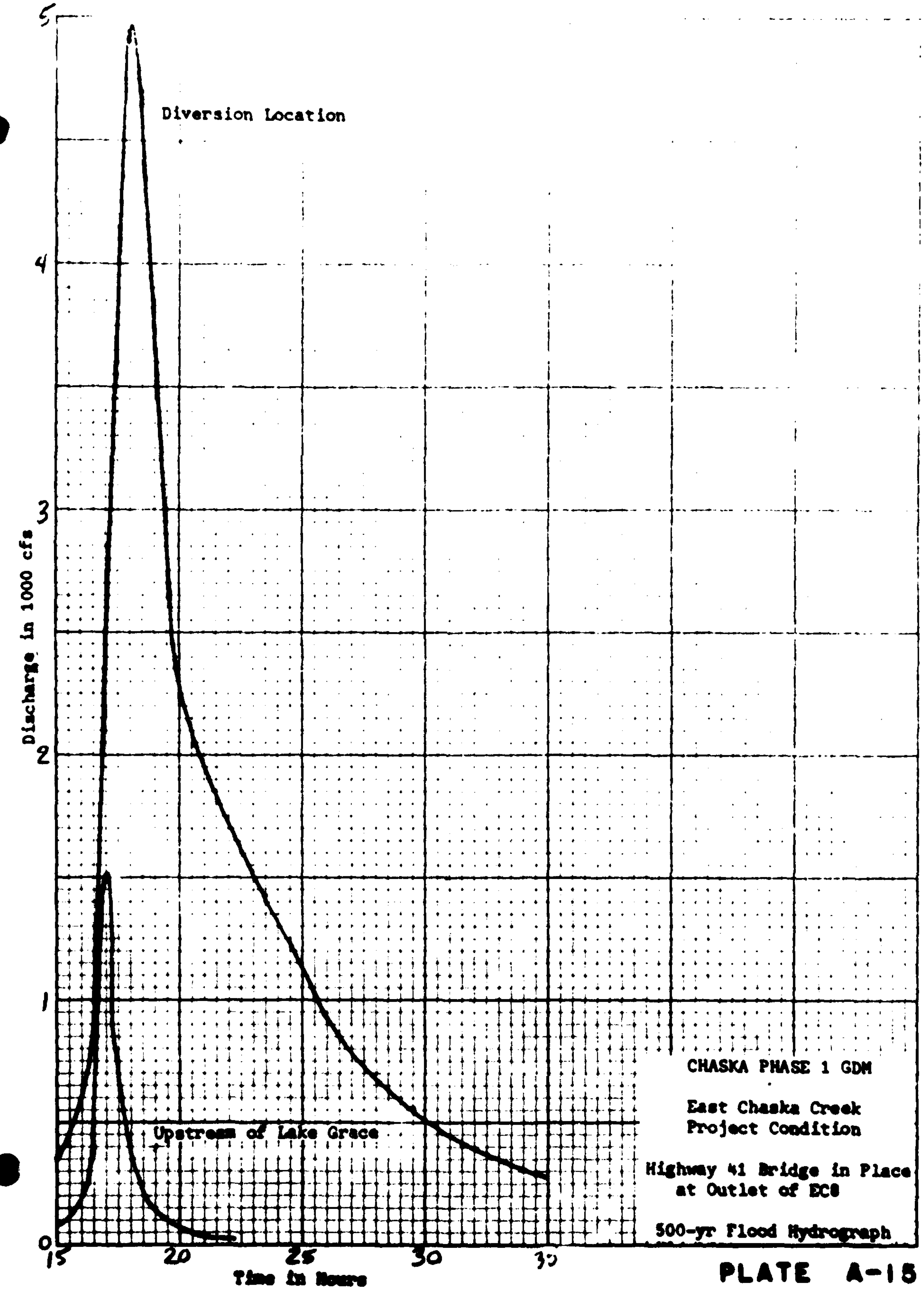

Diversion Location
Upstream of Lake Grace
Discharge in 1000 cfs
Time in Hours
CHASKA PHASE 1 GDM
East Chaska Creek
Project Condition
Highway 41 Bridge in Place
at Outlet of EC8
500-yr Flood Hydrograph

PLATE A-15

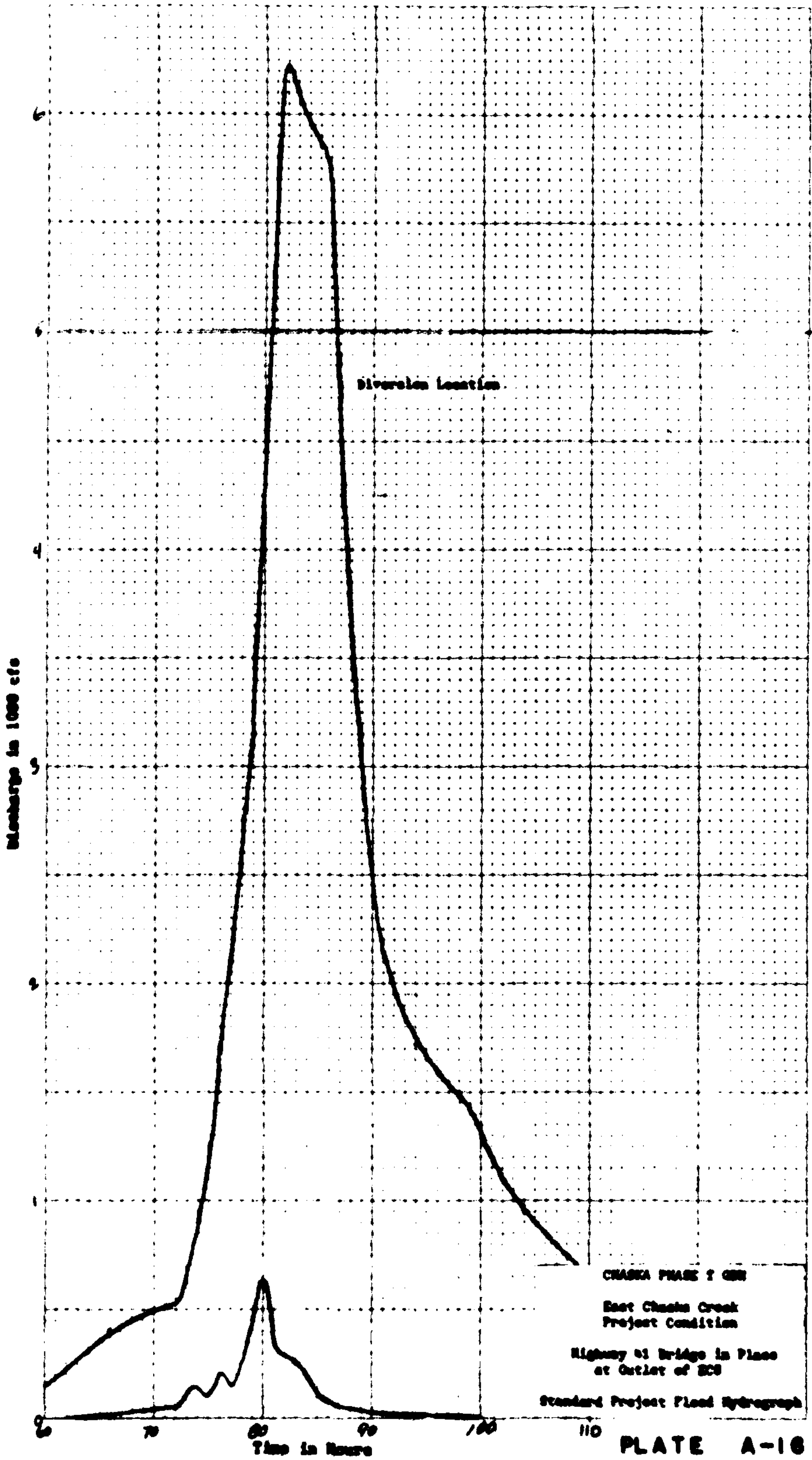
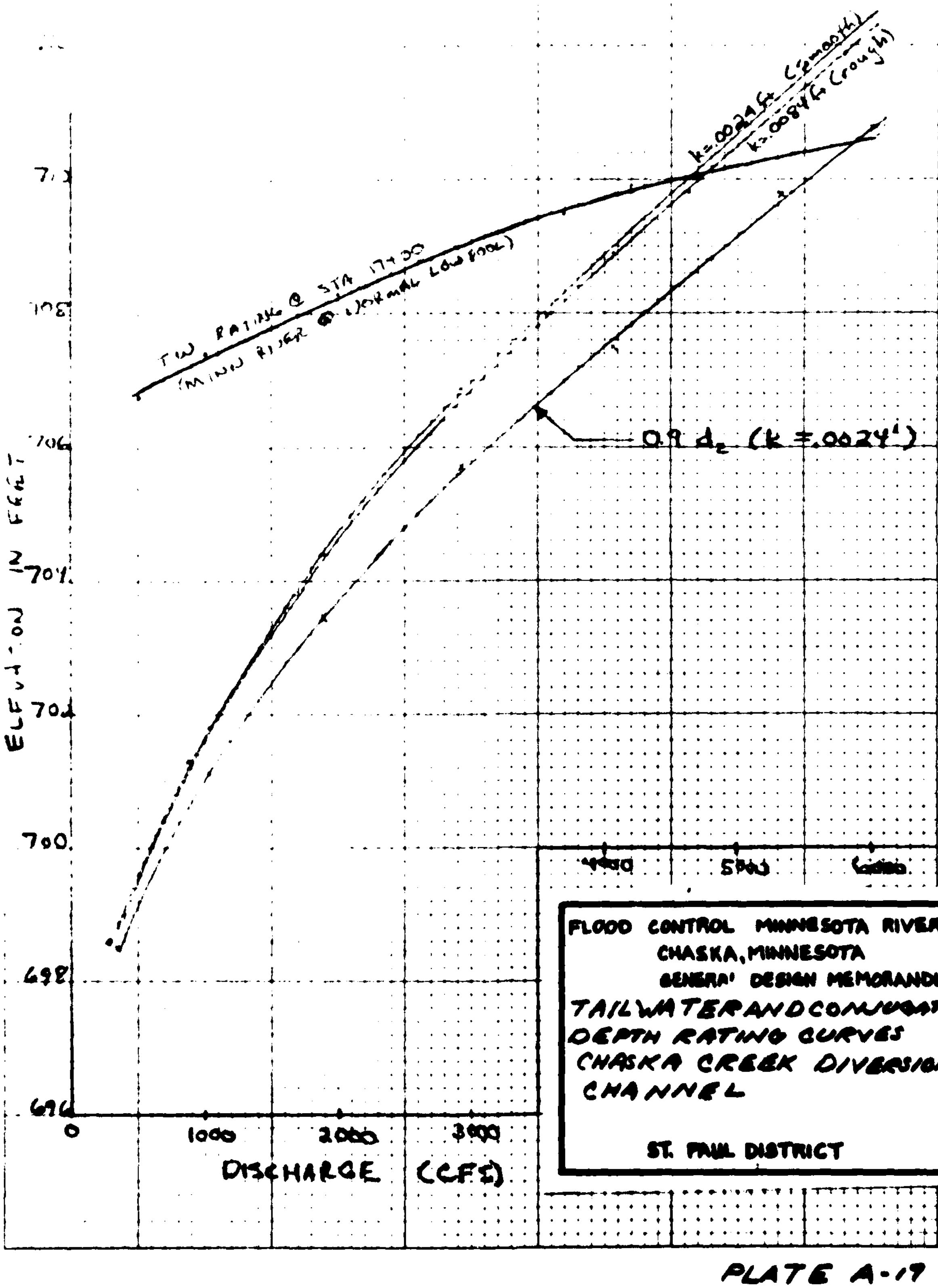

Diversion Location
Discharge in 1000 cfs
Time in Hours
60
70
80
90
100
110
East Chaska Creek
Project Condition
Standard Project Flood Hydrograph

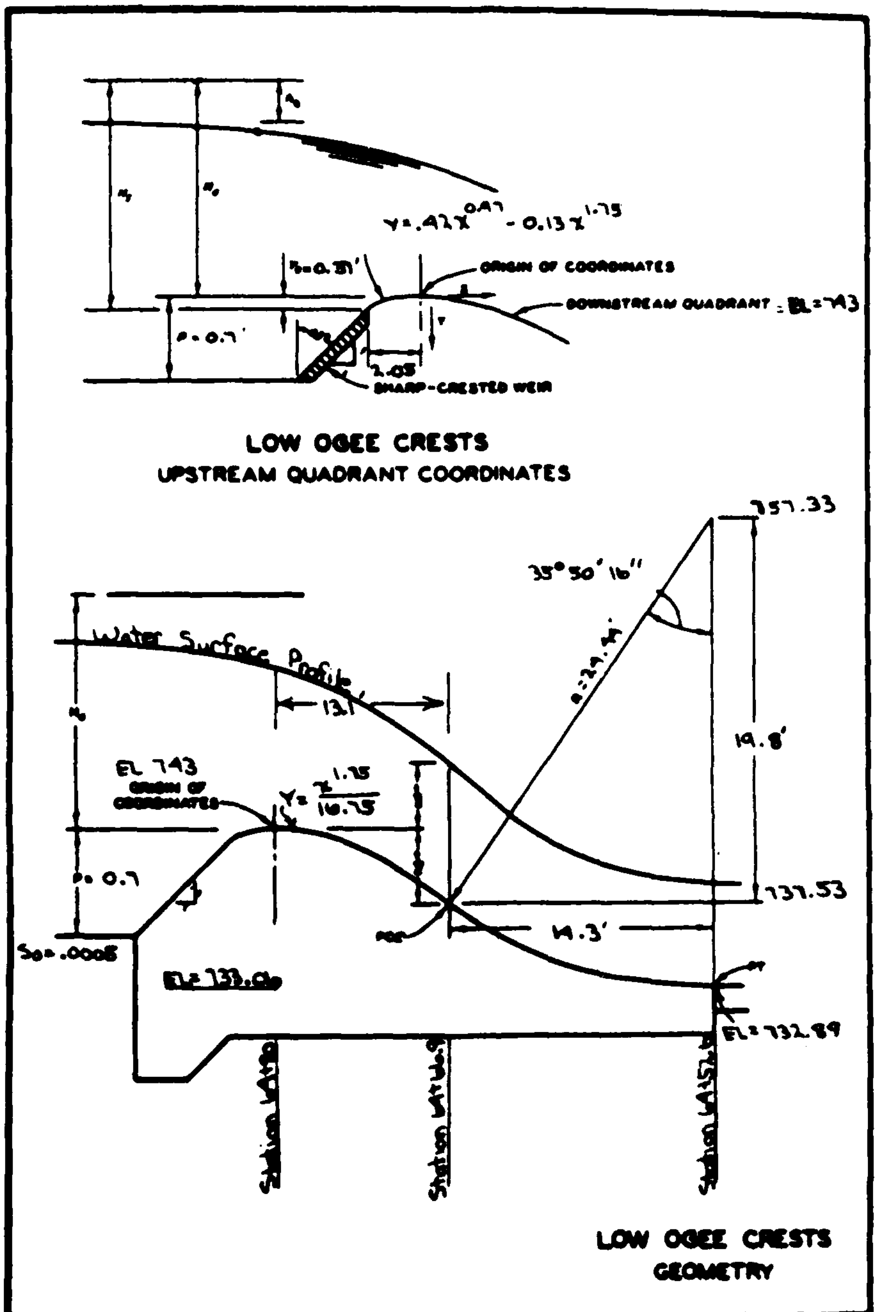
PLATE A-16



FLOOD CONTROL MINNESOTA RIVER
CHASKA, MINNESOTA
GENERAL DESIGN MEMORANDUM
TAILWATER AND CONJUGATE DEPTH RATING CURVES
CHASKA CREEK DIVERSION CHANNEL

ST. PAUL DISTRICT

PLATE A-17

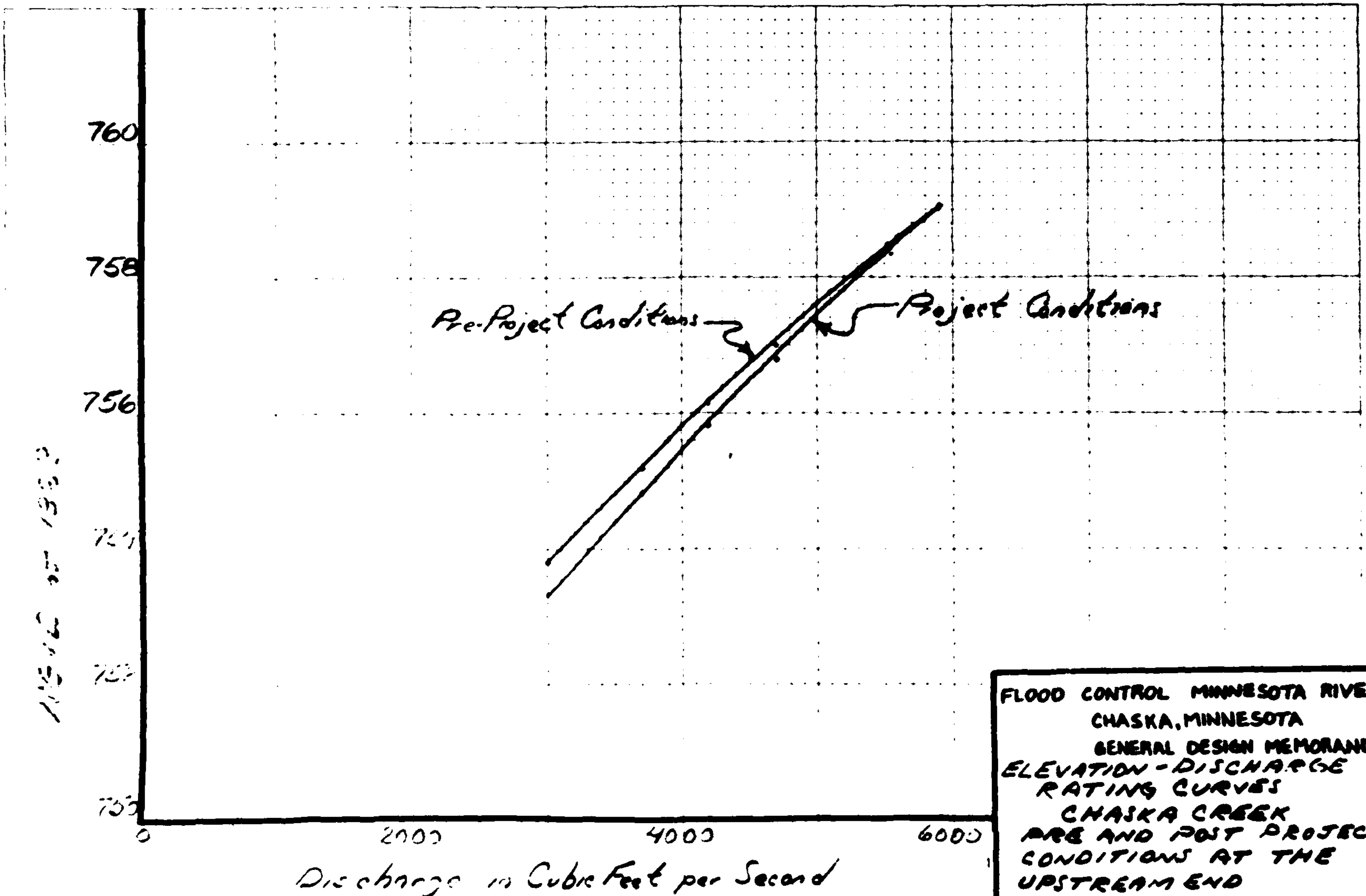


FLOOD CONTROL MINNESOTA RIVER
CHASKA, MINNESOTA
GENERAL DESIGN MEMORANDUM

OGEE SPILLWAY
HYDRAULIC DATA
CHASKA CREEK

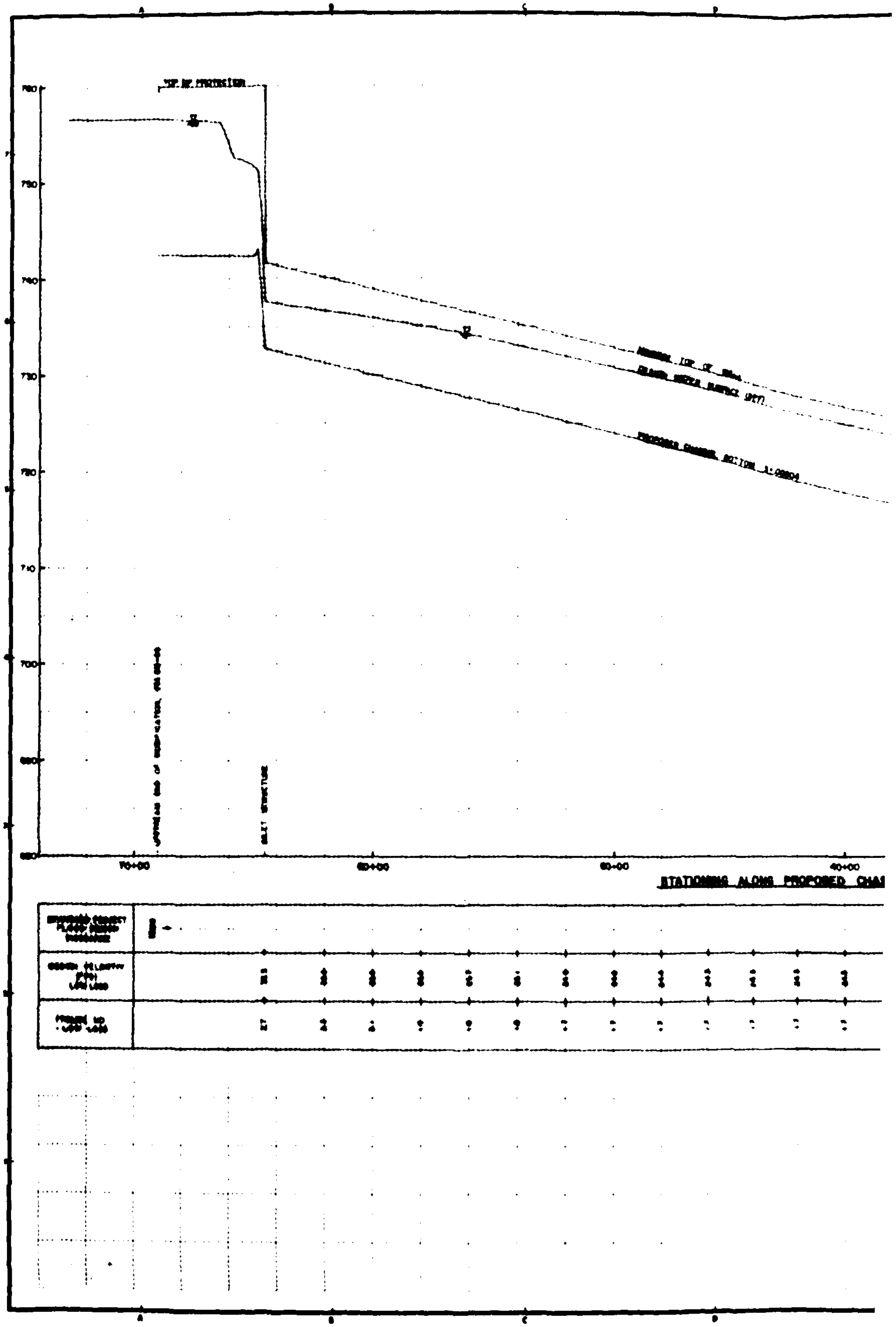
ST. PAUL DISTRICT

PLATE A-18

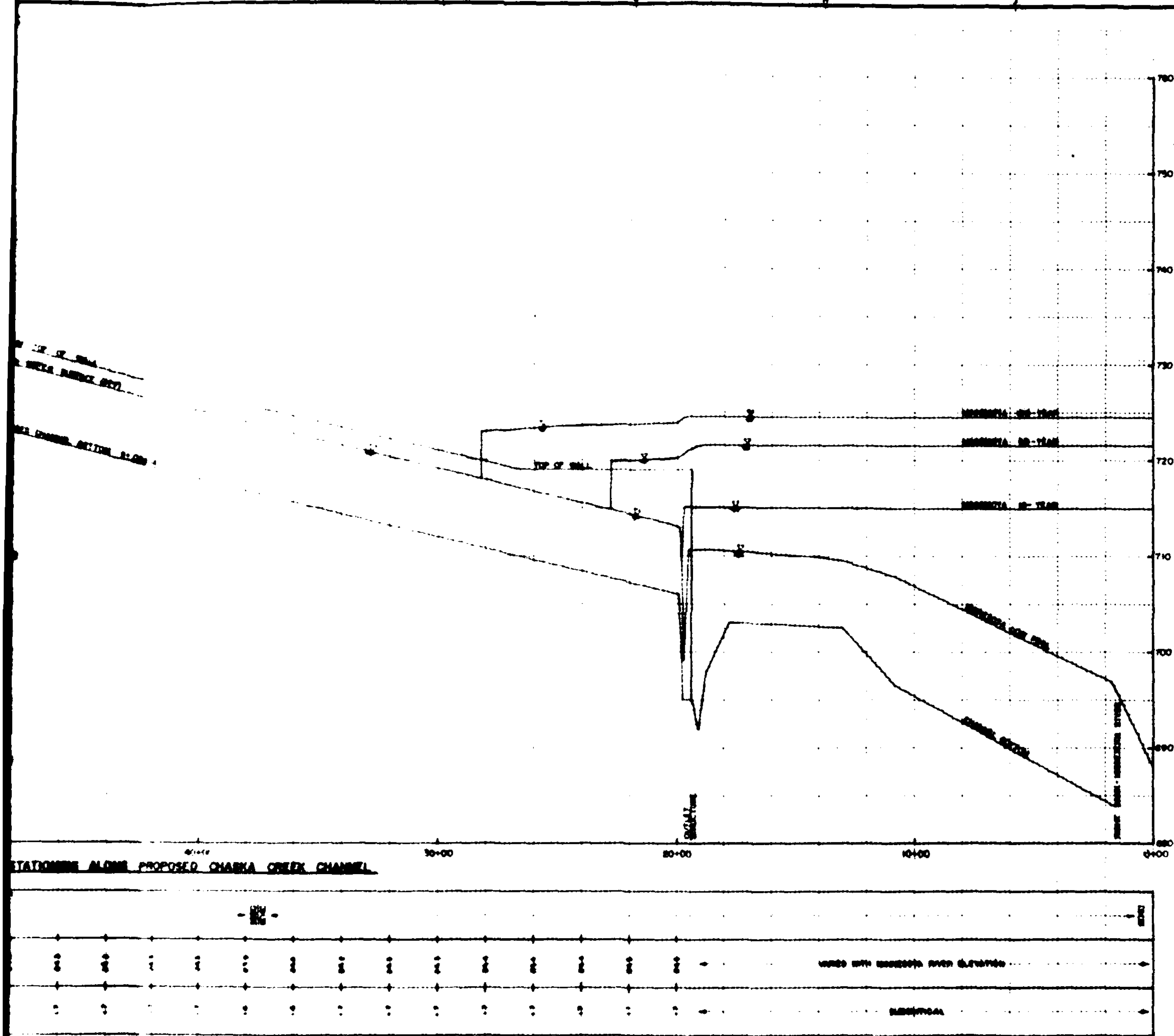


FLOOD CONTROL MINNESOTA RIVER
CHASKA, MINNESOTA
GENERAL DESIGN MEMORANDUM
ELEVATION - DISCHARGE RATING CURVES
CHASKA CREEK
PRE AND POST PROJECT CONDITIONS AT THE UPSTREAM END
ST. PAUL DISTRICT

PLATE A-19



STATIONING ALONG PROPOSED CHA
70+00
60+00
40+00
710
700



SAFETY PAYS

DEPARTMENT OF THE ARMY

P M F

P P C

P M F

SUBMITTED BY

FLOOD CONTROL DESIGN MEMORANDUM

CHASKA, MINNESOTA

CHASKA WEST CREEK

WATER SURFACE PROFILES

PROPOSED CONDITIONS

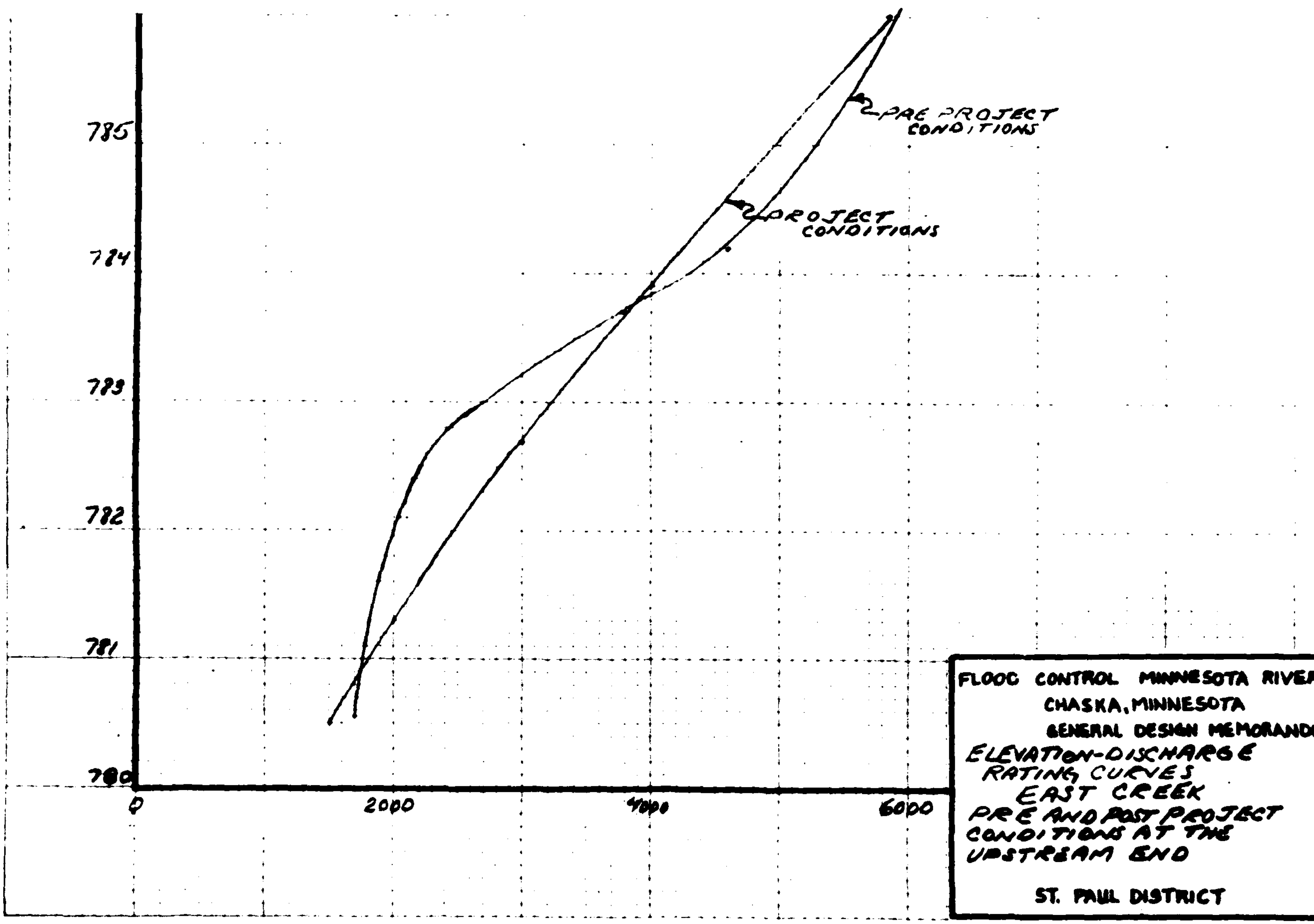
APPROVED

DATE

MARCH 1984

M34-CH-9-8/110

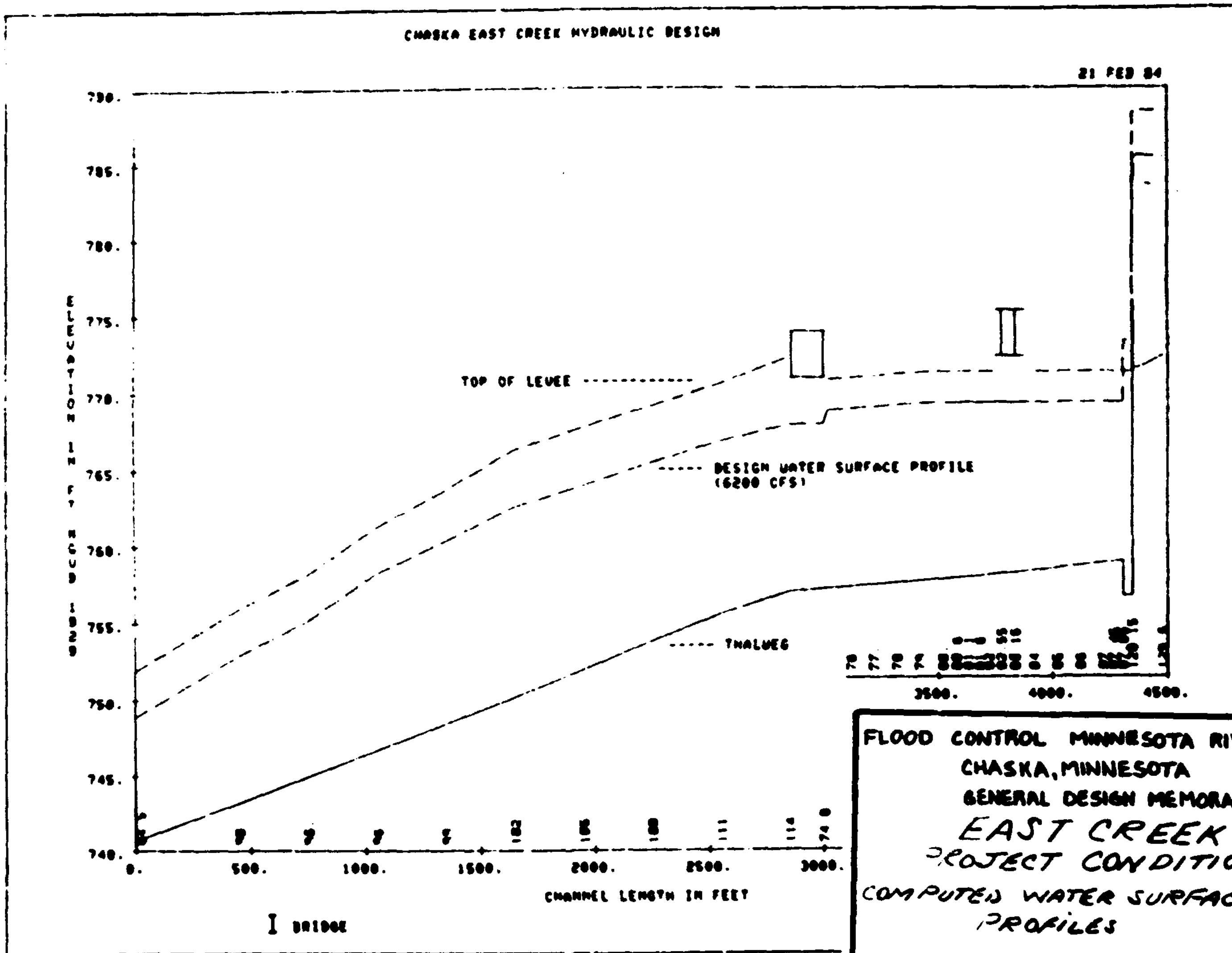
PLATE A-20



FLOOD CONTROL MINNESOTA RIVER
CHASKA, MINNESOTA
GENERAL DESIGN MEMORANDUM
ELEVATION-DISCHARGE RATING CURVES
EAST CREEK
PRE AND POST PROJECT CONDITIONS AT THE UPSTREAM END

ST. PAUL DISTRICT

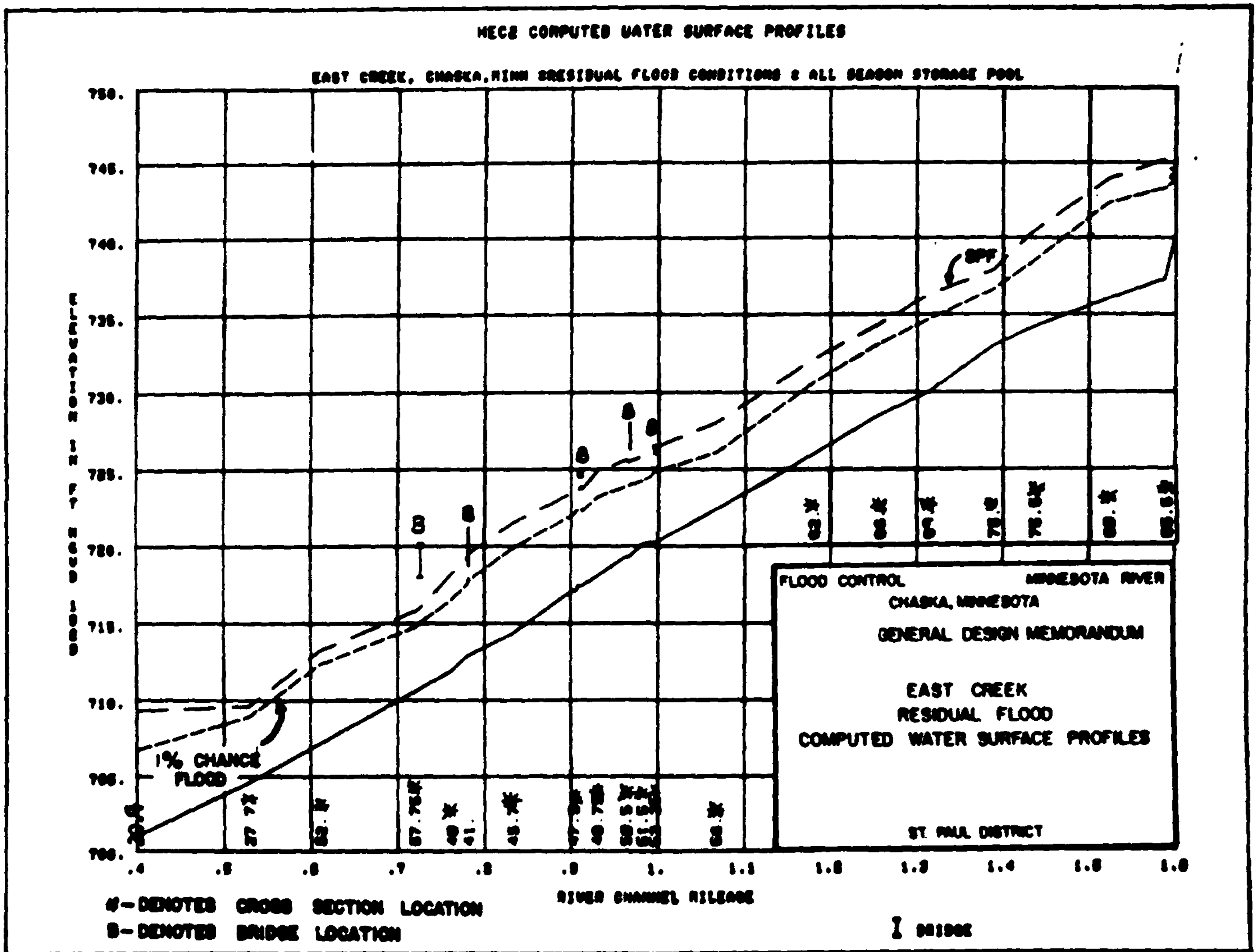
PLATE A-21



FLOOD CONTROL MINNESOTA RIVER
CHASKA, MINNESOTA
GENERAL DESIGN MEMORANDUM
EAST CREEK
PROJECT CONDITION
COMPUTED WATER SURFACE
PROFILES

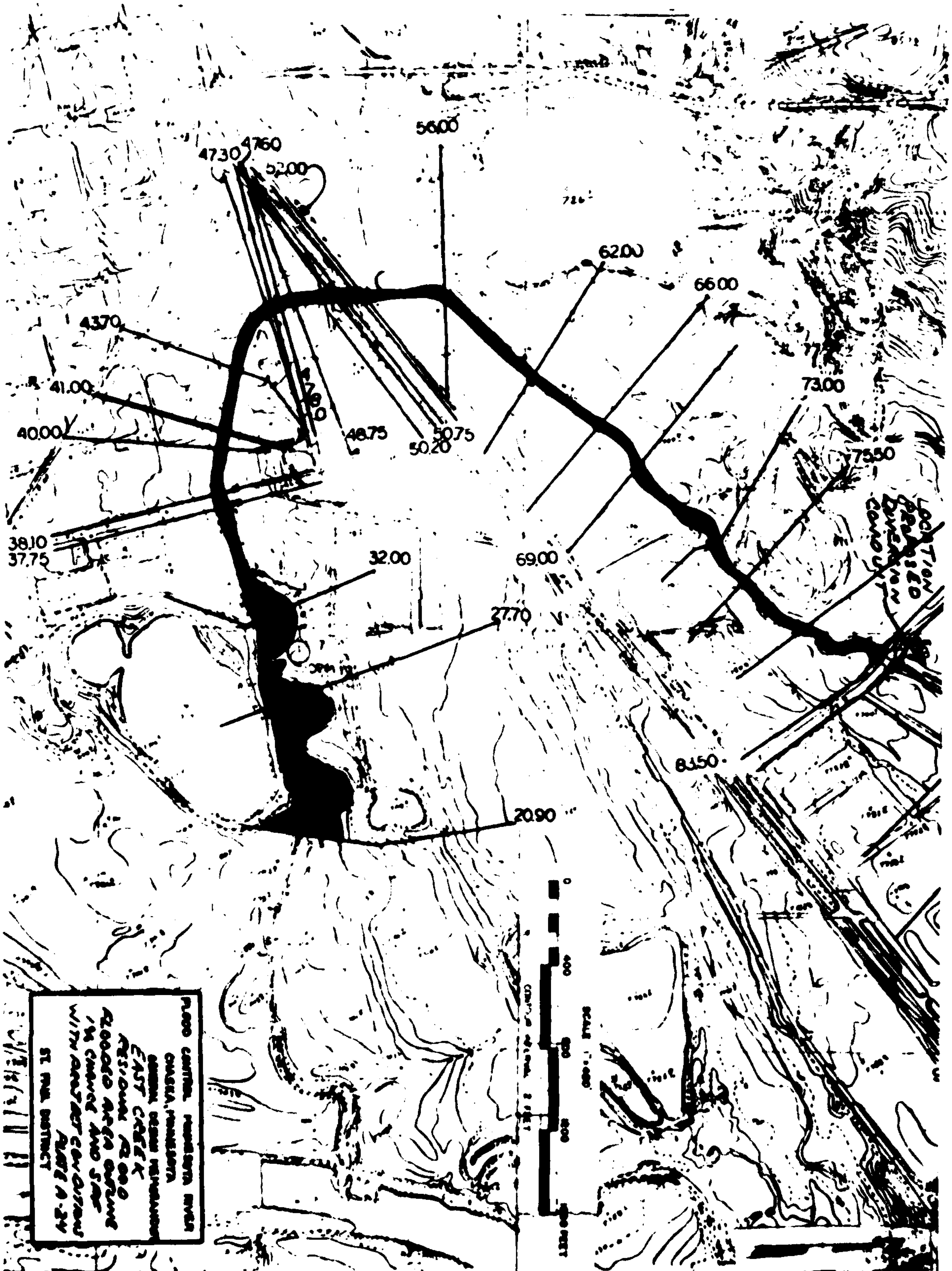
ST. PAUL DISTRICT

PLATE A-22



Note: See Plate A-24 for Cross Section locations

PLATE A-23



56.00
47.30
47.60
52.00
62.00
66.00
43.70
41.00
40.00
48.75
50.75
50.20
73.00
75.50
38.10
37.75
32.00
69.00
27.70
83.50
20.90
EAST CREEK
ST PAUL DISTRICT

7

APPENDIX C

GEOTECHNICAL DESIGN

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TABLE OF CONTENTS - Continued

TABLES

FIGURES

TABLE OF CONTENTS - Continued

PLATES

TOPOGRAPHY

1. The portion of the city of Chaska, Minnesota, where the proposed flood control improvements would be located is within the Minnesota River Valley. The valley trends northeast and is 2.5 miles wide in this reach. The floodplain lies at approximately elevation 705, averages 1 mile in width, and is characterized by extensive marshy areas and lakes. Alluvial and bedrock terraces rise above the floodplain and form regionally prominent benches at elevations 750 and 800. Most of the developed portion of Chaska is situated between elevations 710 and 730 at the upstream limit of a terrace that trends northeast along the base of the valley wall. The river valley walls rise sharply above the floodplain and terraces to form a bluff that grades into a hummocky, poorly-drained regional highland at elevation 850 on the north side of the valley and elevation 900 on the south side of the valley.

2. Chaska Creek emerges from the regional highland in a deep, steep-walled valley on the northwest side of Chaska and flows in a shallow channel around the western and southern edges of the city to the Minnesota River. East Creek emerges from a similar but smaller valley onto a large terrace about 1.5 miles northeast of Chaska. The creek flows southwesterly across the terrace, cuts through the northeast corner of Chaska, and joins the Minnesota River downstream of the city. The normal flow in the two creeks is sustained by groundwater discharging from pervious materials in thick glacial till deposits that comprise the surrounding regional highlands.

GEOLOGY

3. The region surrounding the project area was glaciated extensively during the Pleistoncene Epoch. The glaciers laid down thick deposits of outwash sands and unsorted tills that today form a hummocky, poorly-drained plain dotted with marshes and small lakes. The glacial drift reaches a thickness of 200 to 250 feet and rests on dolomitic limestone and sandstone of the Prairie du Chien and Jordan Formations. The large valley of the present Minnesota River was carved by the glacial River Warren, which carried large volumes of water discharging from the now-extinct glacial Lake Agassiz located in western Minnesota and eastern North Dakota. This river, the ancestor of the Minnesota River, cut deeply into bedrock and formed the terraces that are prominent today. As the flows decreased, the valley was filled to its present level with alluvial sand, silt, and soft clay.

SUBSURFACE INVESTIGATIONS

4. Borings and laboratory testing have been obtained periodically from 1973 through 1983 as the study progressed to the present phase.

5. In 1973, nine borings, ranging in depth from 40 to 150 feet, were taken along the existing flood barrier. As the study progressed, additional borings were taken in 1979, 1980, 1982, and 1983.

6. In the beginning stages only gradation tests, moisture tests, and Atterberg limits were taken on selected jar samples. As the planning process required more detailed analysis, additional laboratory testing was conducted.

7. In 1980 undisturbed samples were taken and triaxial tests performed on samples from borings 80-24MU, 80-26MU, and 80-28MU, which are shown on plates C-15 through C-17. The results of these tests were utilized in the limited reevaluation report.

8. The limited reevaluation report identified areas which required additional investigation, therefore, borings were taken in 1982 and 1983. Triaxial, consolidation, gradation, residual shear, and Atterberg limit tests were taken on selected samples. The results are shown on plates C-17 through C-39.

9. No subsurface investigation has been accomplished along the East Creek alignment because of a recent alignment change resulting from a Value Engineering Study. The subsurface investigation for East Creek will be accomplished during the next phase of the study.

10. In order to better define the base of the aquifer along the Minnesota River levee alignment, additional deep borings should be taken. This information will ensure an adequate design for the relief wells in this reach.

11. For a complete review of all the existing borings for the Chaska Flood Control project, see plate C-1 for boring locations, and plates C-2 through C-9 for the boring log staffs. The borings taken along the proposed project features are shown on plates 1 through 22 of the main portion of the GDM.

SUBSURFACE PROFILE

GENERAL

12. For the purposes of design and analysis, the project has been divided into four reaches. Each reach represents a different type of design due to either the soils encountered or the features being designed.

13. The Minnesota River Levee has been divided into two reaches. reach 1 is along the proposed alignment downstream from the abandoned C.M.St.P. and P. Railroad embankment (station 0+00 to 33+00) where there is up to 25 feet of very soft, highly plastic clay at the surface. Reach 2 is upstream of the railroad embankment (station 33+00

to 95+18) where the levee will be founded on alluvial sediments consisting primarily of fine and medium sand. Boring 73-1M, located near the mid-point of the existing levee, ended in sand at a depth of 152 feet.

14. Chaska Creek and East Creek are each considered to be separate reaches. The Chaska Creek Diversion is reach 3, and East Creek Diversion, reach 4.

15. Bedrock was not encountered in any of the borings. Boring 79-10M was taken to a depth of 100 feet and boring 73-1M was taken to a depth of 150 feet. West of Chaska the Minnesota Department of Transportation found bedrock at a depth of 170 feet, and near Carver, Minnesota, roughly 3 miles upstream, outcroppings of bedrock can be seen.

REACH 1

16. Borings show soft foundation soils along Courthouse Lake from approximately station 8+00 to 30+00. The foundation consists of organic clays for the top 20 to 25 feet. The very soft material generally exists where the natural ground elevation is 703 or less. For example, boring 73-3M has a soft layer of material classified as CH approximately 18 feet thick. Below this soft layer, stiff clay of high and low plasticity extend down to elevation 660.

17. From station 0+00 to 8+00 the foundation does not have the soft inorganic or organic clay which is found in other sections of the reach. Borings 73-7M and 83-61M show stiff clays, silts, and silty gravel. Penetration tests show blow counts averaging 17 blows per foot, with a minimum of 5 blows per foot and maximum of 49 blows per foot.

18. Local citizens have added fill along Courthouse Lake. Borings 80-25M and 80-26M indicate that the fill is classified as silty sands, clayey sands, clay, and silt. In addition to the fill for the existing levee, fill was utilized to build a maintenance storage yard. The storage yard fill contains concrete chunks, silts, sands, and clays; however, unsatisfactory material may also be present.

REACH 2

19. Boring logs show a deep sand foundation separated by thin impervious layers at various elevations throughout the reach (plate C-10). The sand foundation is overlain by a relatively thin semipervious blanket with a varying thickness of 4 to 10 feet. The blanket consists of materials classified as SC, GC, CL, OL, and SM. For example, boring 79-12M shows a 9.75-foot stratified blanket consisting of SP, SC, and SM. Generally, the elevation of the blanket is about 710.0, however, there is a drainage ditch at the landward toe of the existing levee with a minimum elevation of 704 feet.

20. The effective grain size, "D_{10}", of the pervious layer beneath the proposed levee varies from 0.08 mm to 0.20 mm, with a weighted average of about 0.15 mm. Based on D_{10} the permeability can vary from greatest at the top to lowest at the bottom, or vice versa. The pervious material has from 4 to 12 percent fine material with the fine material averaging generally between 6 and 8 percent. There is also some gravel in the area. Downstream of the Minnesota Highway 41 bridge, boring 79-18M shows GP-GM in the upper 10 feet of the pervious layer with a D_{10} of 0.48 mm. Nearer to the river, borings 73-8M, 79-13M, 80-24M, and 73-6M show from 2 to 8 percent gravel in the upper sand layers with D_{10}'s of about 0.18 mm to 0.20 mm, slightly higher than the weighted average. Upstream from the highway bridge, boring 79-17M, approximately 475 feet landward of the levee, shows approximately 40 feet of uninterrupted sand and gravel. The upper 15 feet being classified as GP-GM with an effective grain size (D_{10}) of 0.2 mm. This gravel may or may not be evidence of old creek channels. There is evidence that the settlement and growth of Chaska included the rechanneling of both Chaska and East Creeks.

21. Borings also indicate that a riverside blanket exists in two separate areas within reach 2. The first area is from station 33+50 to 43+50, the second from station 57+00 to 95+18. The riverside blanket in both areas varies in both permeability and thickness. The riverside blanket from station 73+00 to approximately 95+18 is relatively narrow due to the proximity of Chaska Creek. Within this portion of the reach, Chaska Creek closely parallels the existing and proposed levees. Borings indicate that the creek intersects pervious layers extending under the proposed levee, providing a seepage entrance.

22. Boring 79-22M, riverward of the existing levee, shows an impermeable layer 30 feet thick. This layer forms a seepage block between the levee and the Minnesota River, however, topography and borings indicate that this block does not extend past station 38+50.

REACH 3

23. Reach 3 includes Chaska Creek from the area upstream of U.S. Highway 212 to the confluence of the Minnesota River and Chaska Creek.

24. The subsurface profile is typical of alluvial sediments. Borings show a highly stratified substrata with alternating layers of silty sand, clayey sand, silt, low and high plastic clay, and intermittent layers of organic material. The reach is characterized by a high water table. Standard penetration test results are shown adjacent to the boring log staffs on plates C-2 through C-9.

REACH 4

25. The alignment of East Creek as shown in the limited reevaluation report has been changed as a result of a Value Engineering study

completed in December 1983. Time contraints did not allow subsurface investigations along the new alignment, therefore, the subsurface profile description for this reach will be included in the feature design memorandum (FDM).

PROJECT FEATURES

GENERAL

26. Project features and profiles are shown on plates 1 through 32 of the main portion of this general design memorandum (GDM). The following descriptions are a brief summary of the proposed features for the Flood Control Project at Chaska, Minnesota.

MINNESOTA RIVER LEVEE - REACH 1

Levee Section

27. The levee design for this reach calls for an impervious levee to be constructed from station 0+00 to 33+00. The top of levee elevation will vary throughout reach 1 to compensate for anticipated foundation settlement. From station 0+00 to 8+00 the levee will be constructed to elevation 727.5. However, for the remaining portion of the reach the top of levee elevation will be 728.4. The additional 0.9 foot of overbuild is not considered excessive and is within the guidelines shown in EM 1110-2-1913.

28. The levee width and sideslopes are standard throughout the reach. The levee will have a 10-foot top width with 1V on 3H sideslopes, however, from station 8+00 to 20+50 stability berms will be required on both sides of the levee embankment. From station 20+50 to 33+00, only a riverside stability berm will be required.

Erosion Protection

29. Levee erosion protection will consist of topsoiling and seeding.

Inspection Trench

30. An inspection trench will be required in all locations wherethe foundation is not excavated to a depth greater than 6 feet. The trench will have the following dimensions: a 6-foot bottom width, 1V on 1H sideslopes, and a 6-foot depth. The trench will be backfilled with impervious fill.

East Creek Outfall

31. Two 108-inch gated, reinforced concrete pipes will pass the low flows of East Creek through the proposed levee. See the structural design appendix for the structural details of the wingwalls and gates.

AD-A146 985

MINNESOTA RIVER AT CHASKA MINNESOTA FLOOD CONTROL PROJECT GENERAL DESIGN..(U) CORPS OF ENGINEERS ST PAUL MN ST PAUL DISTRICT AUG 84

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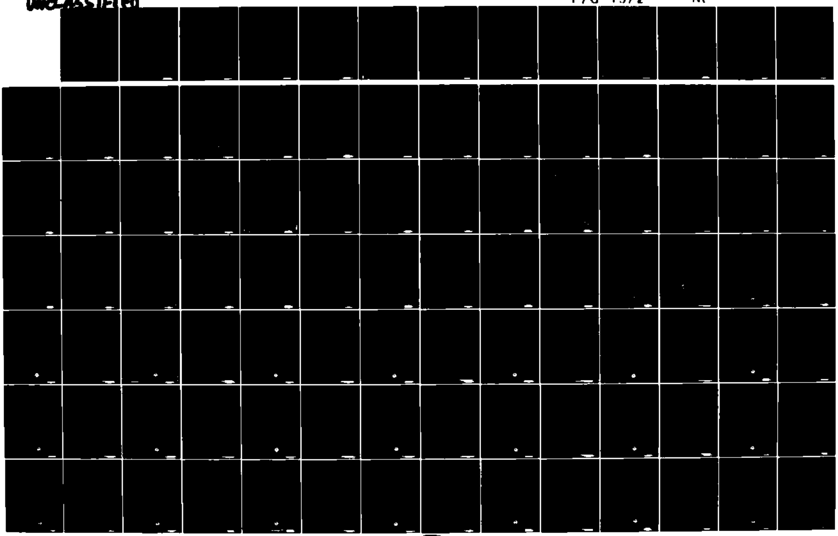
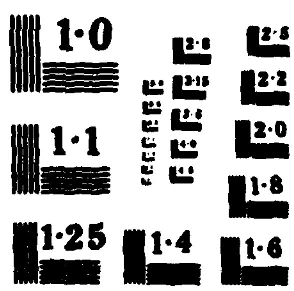
F/G 13/2 NL




1·0
1·1
1·25
1·4
1·6
1·8
2·0
2·2
2·5

It is recommended that all unsatisfactory foundation materials be excavated and replaced with compacted satisfactory material. The limits of excavation for the outfall will be determined for the FDM.

MINNESOTA RIVER LEVEE - REACH 2

Levee Section

32. The proposed levee section will be standard throughout the reach. The existing flood barrier will be stripped and grubbed of all stumps, roots, buried logs, etc., and raised approximately 3 feet with compacted impervious fill. The levee will have a top width of 10 feet, with 1V on 3H sideslopes, and a top of levee elevation of 728.5.

Erosion Protection

33. Levee erosion protection will consist primarily of topsoiling and seeding, however, riprap may be required along the Minnesota River from station 45+00 to 57+00.

Relief Wells and Seepage Berms

34. Analysis indicates that a factor of safety against uplift pressures of 1.50 cannot be met due to the thin blanket and/or deep pervious aquifer within this reach. As a result, a system of relief wells and seepage berms have been designed. A total of 29 relief wells are recommended from station 38+50 to 59+60, and seepage berms from station 59+00 to 75+00. For complete design details see the seepage and uplift analysis on page C-11 of this appendix.

Inspection Trench

35. An inspection trench will be excavated next to the riverward toe of the existing levee from station 54+00 to station 95+18. The trench will have the following dimensions: a 6-foot bottom width, 1V on 1H sideslopes, and a depth of 6 feet. The trench will be backfilled with satisfactory impervious fill to provide a seepage cut-off of thin sand layers that exist intermittently in the blanket materials. Between station 39+00 and station 54+75 the trench excavated for the interceptor pipeline will be utilized as an inspection trench. This trench should exceed the minimum dimensions specified above, and will be backfilled with satisfactory impervious fill. In the remaining areas of reach 2, and where the interceptor trench does not have a 6-foot bottom width and/or 6-foot depth, and between stations 33+50 and 39+00, a trench of these dimensions will be excavated.

Pumping Station

36. The pumping station required for interior flood control will have a capacity of 21,700 gallons per minute. The pumping station will be located at the south end of Pine Street at approximately station 58+50.

37. In addition to the pumping station, two ponding areas have been designed to provide storage for interior flood control. The first area is the portion of the existing Chaska Creek which lies inside the protected area. The second area is located northeast of Courthouse Lake.

CHASKA CREEK DIVERSION - REACH 3

Supercritical Channel

38. The concrete rectangular channel follows basically the same alignment as shown in the limited reevaluation report. The design was changed from a subcritical channel to a supercritical concrete channel as a result of a Value Engineering Study.

39. The bottom of the concrete channel is at or below the natural water table. A drainage system to relieve uplift pressure on the bottom of the concrete channel is currently being designed by an AE firm.

40. The channel has a bottom width ranging from 35 feet upstream of station 37+50, to 37.5 feet downstream of station 37+50. The change in the channel bottom width is the result of two side drainage inlets. The inlets enter the supercritical channel from the right at approximately station 37+50, and from the left just upstream of First Street.

Inlet

41. The approach to the ogee crest and concrete supercritical channel is a riprapped trapezoidal channel with 1V on 3H sideslopes, a 35-foot bottom width, and an approximate 300-foot length. This portion of the reach is through a natural restriction which will require reshaping the natural channel to the limits shown on plate 22.

42. Upstream of the proposed inlet a berm with a top elevation of 760 and road raise are proposed to prevent flood flows from flanking the proposed inlet stucture.

Stilling Basin

43. The terminal structure for the supercritical channel is a Saint Anthony Falls stilling basin. The features of this design include a 23-foot parabolic drop starting at station 20+00, a 50-foot long

concrete basin with bottom elevation of 695, and concrete sidewalls with a top elevation of 719.

Preformed Scour Hole

44. The preformed scour hole at the end of the stilling basin will have 1V on 3H riprapped sideslopes and is designed to dissipate the excess energy from the highly turbulent flow leaving the stilling basin.

Side Drainage Inlets

45. The side drainage inlet on the right side of the supercritical channel consists of an inlet control structure, tranquil flow channel, ogee crest and a rapid flow channel, which discharge into the supercritical channel. The side drainage inlet into the left side of the supercritical channel is a 60-inch gated, reinforced concrete pipe, which enters the supercritical channel at a 30° angle.

Service Road

46. Access to the concrete supercritical channel for maintenance and inspection will be provided by a 15-foot wide, gravel surfaced service road from station 29+00 to 44+00.

Erosion Protection

47. Channel erosion protection will consist of riprap from station 14+87 to 19+27 and station 66+40 to 69+00 of the main channel. Some riprap will be required in portions of the right side inlet channel. All other slopes will be protected from erosion by 4 inches of topsoiling and seeding.

Bridges

48. Four bridges are proposed for this reach. The locations are shown on the layout plates in the main portion of this GDM. Design and analysis of the proposed bridges are currently being performed by an AE firm. The results will be presented in the next phase of the study.

EAST CREEK DIVERSION - REACH 4

Inlet

49. The proposed project starts north of Brandon Boulevard with an inlet control structure, 850 feet of concrete rectangular channel, and a riprapped trapezoidal channel. The riprapped channel provides transition between the concrete channel and the natural channel.

Levee

50. From Engler Boulevard to Crosstown Boulevard an impervious levee is proposed on the left bank of East Creek. The levee will have 1V on 3H sideslopes and a 10-foot top width. Levee erosion protection will consist of topsoiling and seeding.

Box-Type Drop Structure

51. The flow from the natural channel will enter an inlet drop structure at Crosstown Boulevard. The structure will be 40 feet by 40 feet and 25 feet deep. The structure will allow low flows to enter the natural channel, however, when flows exceed the capacity of the 40-inch RCP, all flow will be diverted into a 16-foot by 16-foot box culvert.

Culvert

52. The box culvert will be constructed using cut and cover methods. As shown on the profile (plate 29), the culvert will pass under Highway 212 and the Northwestern railroad.

Stilling Basin and Preformed Scour Hole

53. The stilling basin and preformed scour hole are similar to the Chaska Creek design. The scour hole will have a minimum thalwag elevation of 663.4 and a 48-foot wide riprapped bottom with 1V on 3H riprapped sideslopes.

Downstream Channel

54. A grass-lined channel with levees on both sides will pass the low velocity flows exiting the preformed scour hole to the final drop structure. The channel will have a 94-foot bottom width and 1V on 3H sideslopes. The levees, which parallel the channel, will have a top elevation of 718.0, with a 10-foot top width and 1V on 3H sideslopes. Levee erosion protection will consist of topsoiling and seeding.

Outlet Structure

55. The downstream drop structure dimensions are shown on plate 27.

Bridge

56. Two new bridges will be required for the proposed diversion plan. See plate 31 in the main portion of this GDM for their locations.

DESIGN ANALYSIS

57. The analysis effort for this design memorandum has concentrated on the features which have the potential for the greatest overall

impact on the project. In certain situations geotechnical analyses were not performed because of scheduling changes and/or the lack of subsurface data. These analyses will be performed during the preparation of the appropriate FDM.

SLOPE STABILITY

General

58. The limited reevaluation report presented slope stability analyses in four separate areas of the project. The soil parameters utilized in those analyses were based on limited subsurface data and engineering judgment. As a result of additional data it became evident that embankment stability was critical only in reach 1.

59. As a matter of completeness, the proposed levee and preformed scour hole were analyzed for embankment stability at station 78+00. The results indicated that the slope of the proposed levee and preformed scour hole had factors of safety greater than 4.0.

60. Because of the accelerated schedule, the only stability analysis presented is the end of construction stability case at station 15+55 in reach 1.

Analysis

61. The criteria utilized in this analysis was based on the following references: 1) EM 1110-2-1913, Design and Construction of Levees; and 2) EM 1110-2-1902, Engineering and Design Stability of Earth and Rock-Fill Dams.

62. The computer programs titled, "Slip Circle Slope Stability with Side Forces" (I0013), and "Slope Stability Using Generalized Failure Surfaces" (I0014) were utilized in this analysis. These programs perform slope stability in accordance with EM 1110-2-1902 and are available through the Corps of Engineers' library system.

63. The critical stability section was chosen at station 15+55 based on the following four factors: 1) surveys and soundings; 2) borings and laboratory data; 3) geometry; and 4) total impacts on the proposed project.

64. Soundings taken in 1983 showed that Courthouse Lake exceeded 50 feet in depth, with a slope steeper than 1V on 3H. Borings and testing showed that the foundation adjacent to the existing levee had very low shear strength.

65. Case I (End of Construction) was analyzed at station 15+55. Results of the analysis are shown on plate C-12. All other stability

cases were considered less critical and will be analyzed in the next phase of the study.

Recommendations

66. The following recommendations are based on the stability analysis shown on plate C-12, and are applicable from station 8+00 to 20+50.

a. The centerline of the proposed levee should be offset a minimum of 140 feet from the centerline of the existing flood barrier, which is located on the southeast side of Courthouse Lake.

b. The existing flood barrier should be cut to elevation 708.0 with 1V on 2½H lakeside slopes. The excavated material is considered satisfactory material and should be utilized in the proposed project.

c. Weak soils under the proposed levee prism should be excavated to elevation 690.

d. At the East Creek outfall, all weak foundation soils should be excavated. The excavation limits will be presented in the FDM.

e. Stability berms should be constructed on both the landside and riverside of the proposed levee embankment. The stability berm on the landside should extend between stations 8+00 and 20+50. The riverside stability berm should extend between stations 8+00 and 33+00. Berm fill can be obtained from the existing levee and from required excavation beneath the proposed levee.

f. The proposed levee and outfall should be constructed in the dry.

SEEPAGE AND UPLIFT

General

67. The boring logs along the Minnesota River levee alignment, upstream of the abandoned railroad track (station 33+50), indicate that seepage will be a problem during any flood event experienced in Chaska. During the 1969 flood, which crested at elevation 720.3, considerable underseepage and small sand boils were observed landward of the levee in this area. Records indicated that about 20,000 gallons per minute (gpm) were pumped during the peak of the 1969 flood; however, this figure includes sanitary wastewater, groundwater infiltration to the sanitary system, and other interior runoff. Based upon precipitation records at Minneapolis, Minnesota, the limited reevaluation report roughly estimated between 5,000 and 10,000 gpm of underseepage. Assuming the top of the existing levee through reach 2 is at elevation

725.5±, and the flood stage at that same elevation, an estimate of underseepage for existing conditions (i.e., no remedial measures) would be about 8,700 gpm.

Seepage and Uplift Analysis

68. Seepage and uplift computations were completed for ten sections taken along the Minnesota River levee alignment upstream of the abandoned railroad at station 33+50. These ten sections included all of the previous sections presented in the limited reevaluation report, plus additional sections where new soils information had been obtained. Table C-1 on page C-13 shows the correlation of the new section notation with the notation used in the limited reevaluation report, as well as the applicable soil borings and stationing of each section.

69. Methods for development of the various constants and analysis for seepage uplift pressures were taken from Technical Memorandum 3-424, Volume 1, "Investigation of Underseepge and Its Control - Lower Mississippi Levees," and EM 1110-2-1913, "Design and Construction of Levees." The computations presented on figures 1 through 37, are based on the following assumptions.

a. Given the foundation soil profile of reach 2 (station 33+50 to 95+18) shown on plate C-10, the thin layers and non-linear relationships of the impervious layers shown preclude an assumption that a single thin layer exists between stations 39+50 and 59+00 acting as a boundary condition for seepage and uplift pressures. Therefore, these computations assume that an impervious boundary describing the bottom of the aquifer is a CL-CH layer shown in boring 73-1M at elevation 576.0.

b. While 73-1M describes the profile for section 6, no other borings go deep enough to describe the lower boundary of the aquifer between stations 39+50 and 59+00; therefore, boring 73-1M was superimposed below each of the borings describing sections 7, 8, and 9 as "typical" for the reach. The extention of each boring is shown in dashed lines on plate C-10.

c. Pervious sand layers sandwiched between relatively impervious layers within 6 feet of the ground surface will be cut-off by the inspection trench and have been included as part of the semi-pervious blanket.

d. Due to the topographic relief landward of the levee between the Highway 41 (station 55+00) and Pine Street (station 58+50), the hydraulic grade line determined by X_3 (the effective seepage exit) intersects the ground surface elevation before the hypothetical section; therefore, a seepage block has been assumed to exist at that

TABLE C-1

Seepage and Uplift Analysis
Section Information

Section Number New	Section Number Old	Section Location Stationing	Applicable Boring
1	-	88+00	73-4M, 82-37M, 82-39M
2	-	82+45	83-54M, 83-55M
3	1	77+00	79-20M, 79-21M
4	1A	69+00	73-5M, 80-23M
5	2	64+00	79-19M
6	2A	56+00	73-1M
7	3	52+50	79-14M, 83-60M
8	4	48+00	79-13M, 80-24M
9	4A	42+50	73-6M, 83-59M
10	5	35+50	79-11M, 79-12M, 79-[illegible]

point. This assumption suggests that a higher head exists at the levee toe, and this head was used for design purposes in this reach. This is shown graphically on plate C-11.

e. The flood stage used to compute uplift pressures for both existing and design conditions was assumed at the top of the levee. All seepage quantities discussed were computed for the design 1% chance flood stage.

70. Average horizontal permeabilities of the pervious strata were determined as indicated by the sample calculations shown on plate C-11. Values for the horizontal permeabilities of individual layers were determined from D_{10} grain sizes and figure 17, page 51, of TM 3-424. The vertical permeability of the various layers of soil making up the top stratum was determined by transforming them into a single blanket with a permeability equal to that of the most impervious stratum as indicated by the sample calculation. Values of the blanket permeabilities were based on data suggested in table 38, page 265, of TM 3-424, according to soil classification and total thickness of blanket to the bottom of each stratum. Uplift pressures were analyzed with the water surface at the top of the levee, and table C-2 shows the results of this analysis for both existing and design conditions.

Recommended Design

71. The recommended design for the Minnesota River levee in reach 2 will include relief wells and berms between stations 38+50 and 75+00. Relief wells will be installed between stations 39+50 and 58+50; berm design computations for this reach resulted in berm widths varying from 150 to 300 feet in width, which is too wide for the urban surroundings. Therefore, relief wells are the most cost-effective method to control uplift pressures in this reach. Between stations 59+00 and 75+00 all low areas landward of the levee will be filled to elevation 710.0. Futhermore, a berm will be constructed to elevation 713.0 at the levee toe to a 60-foot width, on 1V on 50H slope, and then sloped to a natural ground surface or the fill surface at 1V on 3H.

Relief Well Design

72. A computer program was used to design relief wells between stations 39+50 and 58+50. The title of the program is, "Design of an Infinite System of Relief Wells," Corps Library Program I0015. The program determines the relief well spacing for various penetrations of the aquifer (40 to 100%), generally as suggested by TM 3-424. The wells were designed to provide a factor of safety of 1.70 against uplift pressures. Runs have been included in this report for 8-inch and 12-inch diameter relief wells at each section; however, the design will use an 8-inch diameter well with a 6-inch annular gravel pack. The wells have been assumed to penetrate 60% of the aquifer, however, this should be optimized for cost-effectiveness in the FDM.

TABLE C-2

Summary Of Seepage And Uplift Analysis For
The Minnesota River Levee
(Station 33+50 to 95+18)
At Chaska, Minnesota

Section Number	Applied Between Stations	Reach Length (ft)	Factor of Safety Existing	Factor of Safety Design	Seepage Quantities Existing** Unit (gpm/ft of levee)	Seepage Quantities Existing** Total (gpm)	Seepage Quantities Design Unit (gpm/ft of levee)	Seepage Quantities Design Total (gpm)
	95+18							
1		818	2.66	2.66	0.23	188	0.23	188
	87+00							
2		700	1.76	1.76	0.32	224	0.32	224
	80+00							
3		500	1.79	1.79	0.17	85	0.17	85
	75+00							
4		900	0.70	1.71	0.32	288	0.32	288
	66+00							
5		640	1.36	2.31	0.17	109	0.17	109
	59+60							
6		425	0.43	1.70	3.60	1,530	0.57*	276
	54+75							
7		475	0.71	1.70	3.92	1,862	0.56*	266
	50+00							
8		600	0.39	1.70	3.42	2,052	0.56*	336
	44+00							
9		550	0.49	1.70	3.20	1,760	0.56*	308
	38+50							
10		500	1.58	1.58	1.19	595	1.19	595
	33+50							

ESTIMATED TOTAL SEEPAGE: Existing = 8,693 Design = 2,675

*Figures represent only the seepage passing the well seepage for the design condition. The well system will intercept approximately 13,625 gpm.

**Seepage quanities with water surface elevation at 725.5 with no remedial seepage measures in place.

73. The reach between stations 38+50 and 58+50 has been divided into two subreaches for design of the relief well system. A typical section was chosen for each subreach and a single average horizontal permeability, thickness of pervious layer, vertical permability, and thickness of top layer were used to design the relief well system. Section 8 was chosen for the reach between stations 38+50 and 54+75, and section 6 was chosen to design the well system between stations 55+00 and 58+50. Table C-3 shows a summary of the results from the relief well design.

TABLE C-3

Relief Well Design At Chaska, Minnesota
Minnesota River Levee
(Stations 38+50 to 58+50)

Stationing	Well Spacing (ft)	No.* of Wells	Section Used For Design	Elevation of Top of Riser	Seepage Quantities: Passing System (gpm/ft)	Well Flow At Design Conditions (gpm/well)	(gpm)
38+50 - 54+75	75	21	8	707.0**	0.56	527.3	10,810
55+00 - 58+50	52	8	6	709.0	0.57	375.4	2,815
				ESTIMATED TOTAL WELL FLOW (GPM) =			13,625

*Number of wells includes a well at a half spacing at each end of the well system; therefore, seepage quantities shown are for 20.5 and 7.5 wells, respectively.

**The top of riser elevation from approximately station 49+60 to 54+75 will be 709.0.

74. Because of asethetics and the potential for the wells to flow quite frequently, the relief wells will be set in manholes and each will be connected directly to the interceptor pipeline. A berm will be provided, as required, to insure 4 feet of cover above the top of riser elevation for frost protection.

SETTLEMENT

75. Settlement computations were completed for the section shown on plate C-12 using a computer program entitled, "Computer Program for Determining Induced Stresses and Consolidation Settlements Under Varied Loading Conditions (CSETT)," dated April 1983. The section, located at station 15+55, will induce about 1.75 feet of settlement at the

centerline of the levee. Assuming that 50% of the settlement occurs during construction, an overbuild section of 0.9 foot would be required. Further design of the overbuild section will be completed in the FDM.

DISPOSAL

76. Excavated material from beneath the levee extension in reach 1 would be used in landward and riverward berms. Suitable material excavated from the diversion channels would be utilized in the proposed levee and East Creek by-pass structure embankments. Excess material from channel excavations would be disposed of in overburden areas as part of the expanded recreational areas in the vicinity of Courthouse Lake. Other potential disposal areas, if required, include fill areas in the Jonathan development and the proposed new Highway 41 embankment area. However, final locations of suitable disposal areas, if needed, will be determined during the next phase of the study.

SOURCE OF CONSTRUCTION MATERIALS

RIPRAP AND BEDDING

77. Riprap and bedding of adequate quality can be obtained from limestone quarries, developed in the Prairie du Chien Formation, located on the south side of the Minnesota River valley within [illegible] miles of Chaska.

CONCRETE AGGREGATE

78. Concrete aggregate of adequate quality can be obtained from continuously operating natural aggregate and crushed rock sources in the Minneapolis-St. Paul, Minnesota, metropolitan area. The distance from the project to reliable sources in this area would be [illegible]5 to 50 miles. Closer sources located within 10 miles of Chaska exist but produce concrete aggregate on an intermittent basis. Although the closer sources have not been tested or used for Corps of Engineer projects, information obtained from the Minnesota Department of Transportation indicates this material would be adequate as a concrete aggregate.

LEVEE FILL

79. Levee fill would consist of useable material obtained from the channel excavations. A plentiful supply of impervious glacial till is available from the surrounding uplands in the event sufficient quantities are not obtainable from channel excavations.

TABLE C-4

Corps Library Program I0015
Definition of Variables

Datum	Elevation of ground surface at landside levee toe (feet above N.G.V.D).
D	Thickness of pervious sublayer.
FK	Coefficient of permeability of pervious sublayer. Normally called K_f (fpm).
X3	Distance from landside levee toe to effective seepage exit (ft).
S	Distance from landside levee toe to effective seepage entry (ft).
H	Height of levee above Datum (ft).
WHT	Difference in elevation between Datum and top of riser pipe. May be (+) or (-) (ft).
RL	Length of riser pipe above well screen (ft).
DIA	Inside diameter of well screen (in).
RW	Effecitve radius of well screen and surrounding gravel pack (ft).
FREE	Design freeboard on levee (ft).
WD1	Penetration of well into pervious sublayer (%/100).
F	Design factor of safety for relief wells.
ZT(I)	Effective layer thickness for uplift for semipervious layer (I=1,4) (ft).
GAM(I)	Unit weights corresponding to ZT(I) for uplift computations (pcf).
K_{b1}	Coefficient of vertical permeability for semipervious blanket (fpm).
F.S.	Existing factor of safety against uplift.
SP	Well spacing (ft).

TABLE C-4 - Continued

QW	Total flow into each well with water surface at top of levee (gpm).
HW	Elevation of top of riser pipe plus all head losses in the well minus the datum elevation . May be (+) or (-) (ft).
HAV1	Net average head in plane of measured above HW (ft).
[illegible]	Midpoint uplift factor.
[illegible]	Flow into wells per foot of reach with water surface the distance FREE below the top of levee (gpm).
QS	Total seepage flow which passes the levee with the wate surface FREE below the top of the levee (gpm).
X	Extra length beyond ends of wells for use in calculating total seepage intercepted by wells (ft).
[illegible]	Net head beneath top stratum at midpoint between wells above HW (ft).

BORING EVALUATION SHEET

PROJECT: CHASKA - MN RIVER LEVEE

BORING NO. : 82-37M, 39M, 73-4M

DATE: JAN 84

ELEV. TOP OF FLOOD BARRIER: 729.0

FOR BORINGS SEE SECTION

BLANKET

SOIL UNIT	TOP ELEV.	$K_v \times 10^4$ (1)	γ_m	Z_i	F_t (6)	Z_b	Z_t	ΣZ_b	ΣZ_t	ΣWT. (5)	$\Sigma WT./\gamma_w$
SM-ML	720	16	53.5	8.5	.5	4.25	8.5	8.25	12.5	704.8	11.3
CL	711.5	8	62.5	4.0	1	4.0	4.0	4.0	4.0	250.0	4.0

MINIMUM $K_v \times 10^4$ = 8 FPM

(1) SEE PAGE 265 T.M. 3-424 (2) SEE PAGE 44 T.M. 3-424
(3) G= GRADATION, P=PERMEABILITY TEST, A=ASSUMED VALUES
(4) SEE PAGE 51 T.M. 3-424 (5) WT.= $Z_t \cdot \gamma'_m$ (6) F_t=TRANS.FACTOR

PERVIOUS ZONE

SOIL UNIT	TOP ELEV.	d	D_{10}	(4) SOURCE	(3) K_h	$\Sigma K_h \cdot d$	D= Σd
SP	707.5	5.0	0.11	A	.052	0.26	5.0
OL	702.5	4.5	—	—	—	—	—
SP	697	2.5	0.11	A	.052	0.13	7.5
SP	694.5	6.0	0.09	A	.027	0.162	13.5
SP	688.5	13.5	0.11	A	.052	0.702	27.0
	675	—	—	—			
						1.254	

K_f= 0.046 FPM, c= 0.0088, X_3= 113.2 FT

SUMMARY COMPUTATIONS

Z_t-TOP ELEV	H	S	X_3	H_0	X	H_x	$\Sigma WT./\gamma_w$	F.S.
720.0	9	126.5	113.2	4.25	0	4.25	11.3	2.66

V. scale
1" =

Figure 1

$L = 62'$ $\qquad X_1 = \dfrac{\tanh(0.0088)(62)}{0.0088} = 56.5'$ $\qquad L_2 = 70'$ $\qquad S = 56.5 + 70 = 126.5'$

$H = 9'$

$\delta = \dfrac{27}{126.5 + 113.2} = 0.113$ $\qquad H_b = 9\left(\dfrac{113.2}{126.5 + 113.2}\right) = 4.25'$

$Q_s = 0.113(0.044)(6.1)\left(7.48\,\dfrac{GPM}{FPM}\right) = 0.23$ GPM / FT OF LEVEE

SEEPAGE CASE 7 = SEMI-PERVIOUS BLANKET (BOTH SIDES)

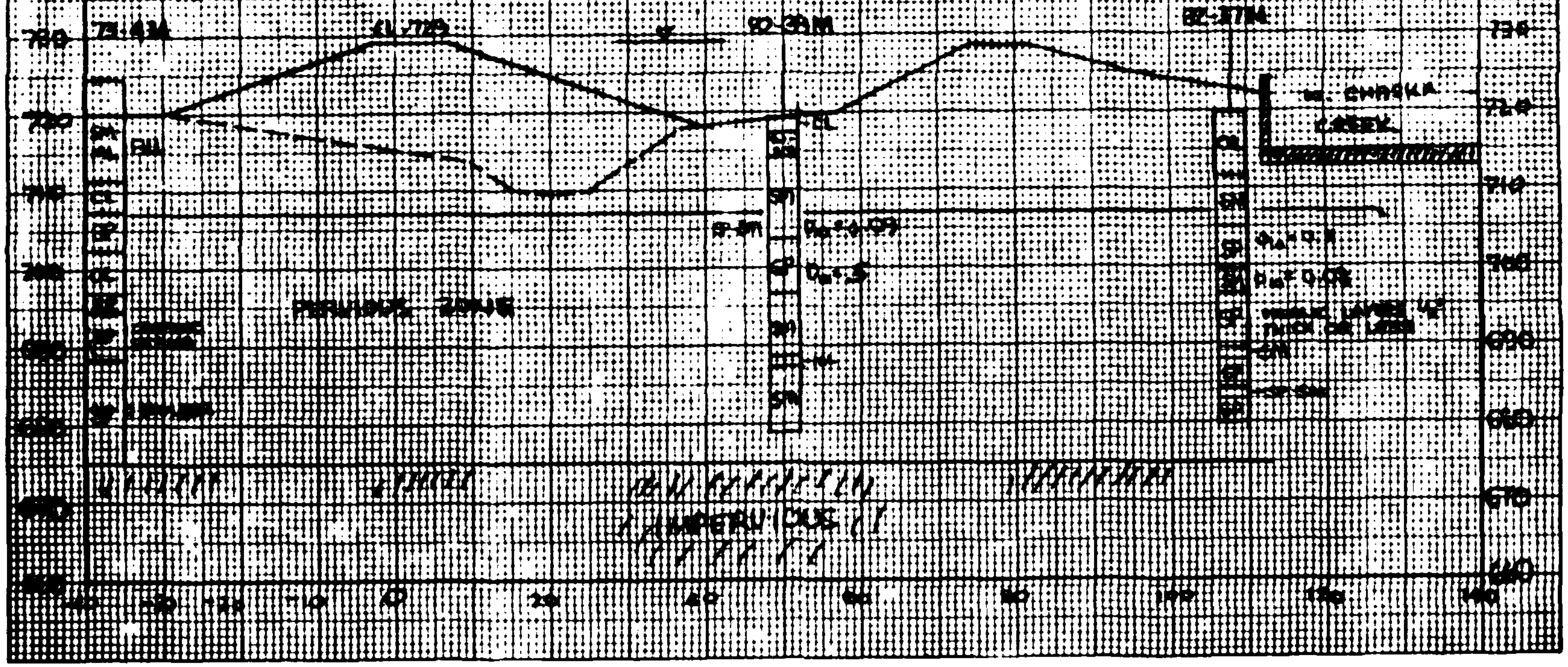


Figure 2

BORING EVALUATION SHEET

PROJECT: CHASKA - MN RIVER LEVEE

BORING NO. : 83-55M, 54M

DATE: JAN 84

BLANKET

ELEV. TOP OF FLOOD BARRIER: 728.5

SOIL UNIT	TOP ELEV.	(1) $K_v \times 10^4$	γ_m	z_i	(6) F_t	z_b	z_t	Σz_b	Σz_t	(5) ΣWT.	ΣWT./γ_w
SC	715	6	62.5	2.8	1	2.8	2.8	7.5	9.7	590.8	9.47
SM	712.2	20	57.5	3.1	.3	.93	3.1	4.7	6.9	415.9	6.66
SC	709.1	6	62.5	3.8	1	3.8	3.8	3.8	3.8	237.5	3.81

MINIMUM $K_v \times 10^4$ = 6 FPM

(1) SEE PAGE 265 T.M. 3-424 (2) SEE PAGE 44 T.M. 3-424
(3) G= GRADATION, P=PERMEABILITY TEST, A=ASSUMED VALUES
(4) SEE PAGE 51 T.M. 3-424 (5) WT.= $z_t \cdot \gamma'_m$ (6) F_t=TRANS.FACTOR

PERVIOUS ZONE

SOIL UNIT	TOP ELEV.	d	D_{10}	(4) SOURCE	(3) K_h	$\Sigma K_h \cdot d$	D=Σd
SW-SM	705.3	4.4	0.18	G	.16	0.704	4.4
SP-SM	700.9	0.4	0.08	A	.02	0.008	4.8
ML	700.5	1.2	—	—	—	—	4.8
SP-SM	699.3	2.0	0.09	A	.027	0.054	6.8
SW-GM	697.3	2.0	0.14	A	.092	0.184	8.8
SW-SM	695.3	3.0	0.14	A	.092	0.276	11.8
SM	692.3	3.4	—	—	—		11.8
SP	688.9	3.6	0.08	A	.02	0.072	15.4
SM	685.3		—	—	—		
						1.298	

K_f= 0.084 FPM, c= 0.0079 , X_3= 127.2 FT

SUMMARY COMPUTATIONS

z_t-TOP ELEV	H	S	X_3	H_0	X	H_x	ΣWT/γ_w	F.S.
715	13.5	191.1	127.2	5.39	0	—	9.47	1.76

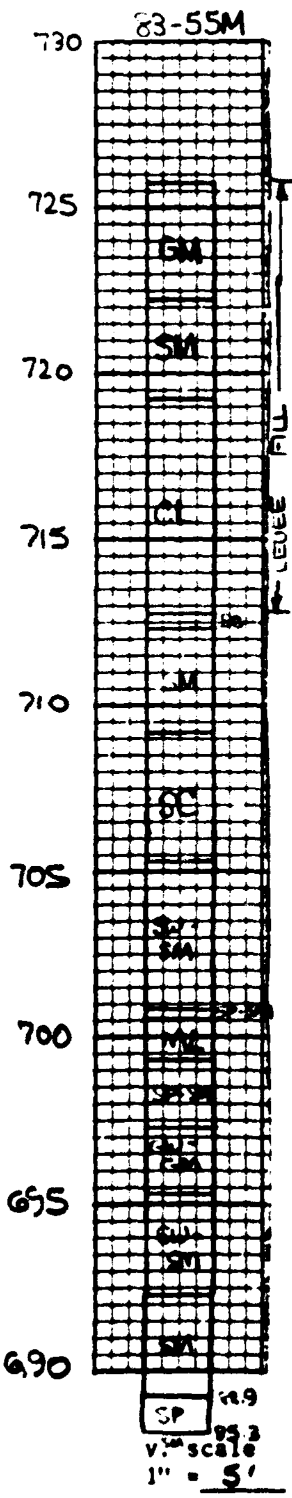


Figure 3

ASSUMPTION— EFFECTIVE SEEPAGE ENTRY AT EDGE OF CONCRETE CHANNEL THROUGH PERVIOUS FROST LAYER AND OR WEEP HOLES. $L_1 = 105'$

$X_1 = \frac{\tanh (0.0079)(105)}{.0079} = 86.1'$

SEEPAGE CASE 7 - SEMI-PERVIOUS BLANKET (BOTH SIDES)

$L_2 = 105'$ $\quad H = 13.5'$ $\quad L_3 = \infty$ $\quad X_3 = 127.2'$ $\quad S = 86.1' + 105' = 191.1'$

$h_0 = 13.5\left(\frac{127.2}{191.1 + 127.2}\right) = 5.39'$ $\qquad i = \frac{18.4}{191.1 + 127.2} = 0.348$

$Q_S = 0.048(.084)(10.5)\left(7.48\frac{GPM}{CFM}\right) = 0.317$ GPM/FT. OF LEVEE

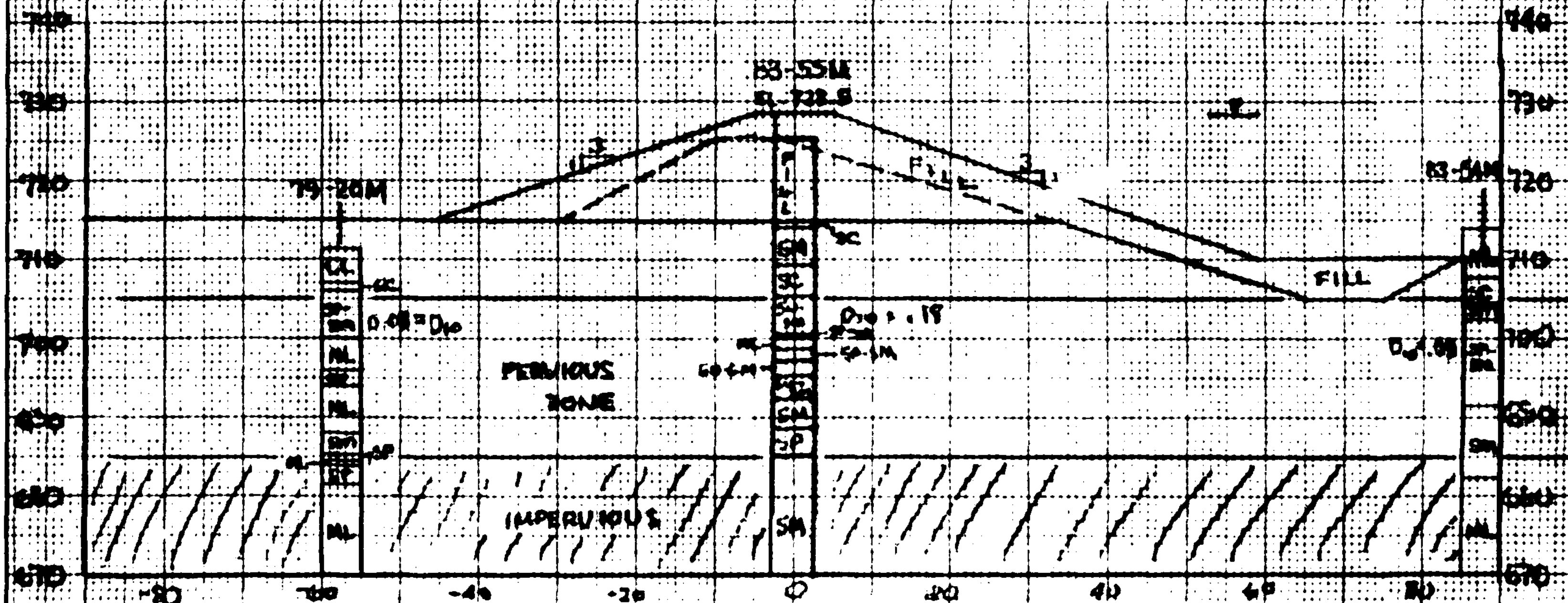
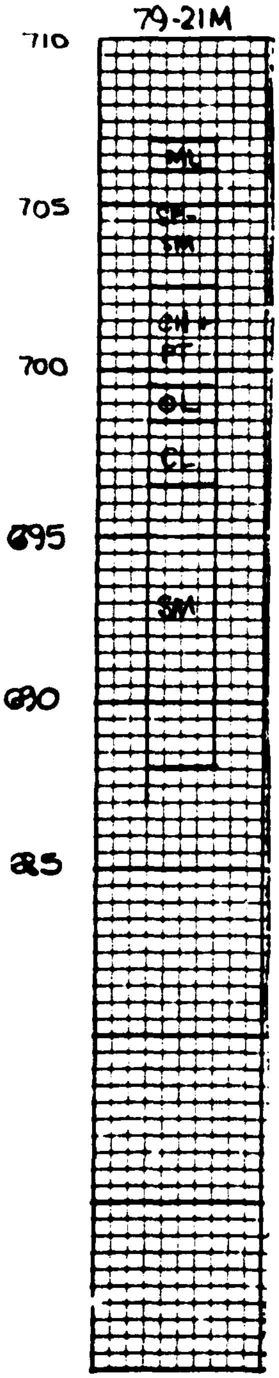


Figure 4

BORING EVALUATION SHEET PROJECT: CHASKA - MN RIV. LEVEE

BORING NO. : 79-21M, 20M DATE: 18 JAN 1984



BLANKET ELEV. TOP OF FLOOD BARRIER: 726.5

SOIL UNIT	TOP ELEV.	$K_v \times 10^4$ (1)	γ'_m	Z_i	F_t (6)	Z_b	Z_t	ΣZ_b	ΣZ_t	Σ WT. (5)	Σ WT./γ_w
CL	709.5	6	62.5	2.6	1	2.6	2.6	10.25	10.25	632	10.13
CL	710	6	62.5	3.1	1	3.1	3.1	10.75	10.75	663.3	10.63
SC	706.9	6	62.5	0.9	1	0.9	0.9	7.65	7.65	469.5	
SP-SM	706	92	67.5	3.5	0.07	0.25	0.25	6.75	6.75	413.2	
CH	702.5	6	60	2.0	1	2.0	2.0	6.5	6.5	396.3	
OL	700.5	6	60	2.0	1	2.0	2.0	4.5	4.5	276.3	
CL	698.5	6	62.5	2.5	1	2.5	2.5	2.5	2.5	156.3	

MINIMUM $K_v \times 10^4$ = 6 FPM

(1) SEE PAGE 265 T.M. 3-424 (2) SEE PAGE 44 T.M. 3-424
(3) G= GRADATION, P=PERMEABILITY TEST, A=ASSUMED VALUES
(4) SEE PAGE 51 T.M. 3-424 (5) WT.= $Z_t \cdot \gamma'_m$ (6) F_t =TRANS.FACTOR

PERVIOUS ZONE

SOIL UNIT	TOP ELEV.	d	D_{10}	(4) SOURCE	(3) K_h	$\Sigma K_h \cdot d$	D= Σ d
SP-SM	696	8	0.08	A	0.02	0.16	8
SP-SM	688	2	0.14	A	0.092	0.18	10
	686						

K_f= 0.034 FPM, c= 0.013 , X_3= 78' FT

SUMMARY COMPUTATIONS

Z_t-TOP ELEV	H	S	X_3	H_0	X	H_x	Σ WT./γ_w	F.S.
710.0	21.5	204.5	78	5.94	0	5.94'	10.63	1.79
709.5	21.5	204.5	78	5.94	0	4.02'	10.13	2.52

v. scale
1" = 5'

ASSUMPTIONS

1) UPPER SP-SM LAYER IS POSITIVELY CUT-OFF BY FILLING THE WEST CHASKA CREEK CHANNEL.

2) ASSUME SM LAYER IS REALLY SP-SM & SM MIXTURE OF LAYERS - USE AN AVERAGE PERMEABILITY FROM BORING 79-17M.

$$X_1 = \frac{\tanh[(0.013)(140')]}{0.013} = 73'$$

SEEPAGE CASE 7 - SEMI-PERVIOUS BLANKET (BOTH SIDES)

$L_1 = 140'$ $\quad L_2 = 131.5$ FT $\quad S = X_1 + L_2 = 73' + 131.5' = 204.5'$

$L_3 = \infty$ $\quad H = 21.5$ FT $\quad \beta = \frac{10}{204.5 + 78} = 0.035$

$$h_0 = 21.5\left[\frac{78}{204.5 + 78}\right] = 5.94'$$

$$H_{30} = 5.94' e^{-.013(30)} = 4.02'$$

$$Q_S = 0.035\,(0.034)(18.5)\left(7.48\,\frac{GPM}{FT^3/M}\right) = 0.165 \text{ GPM/FT OF LEVEE}$$

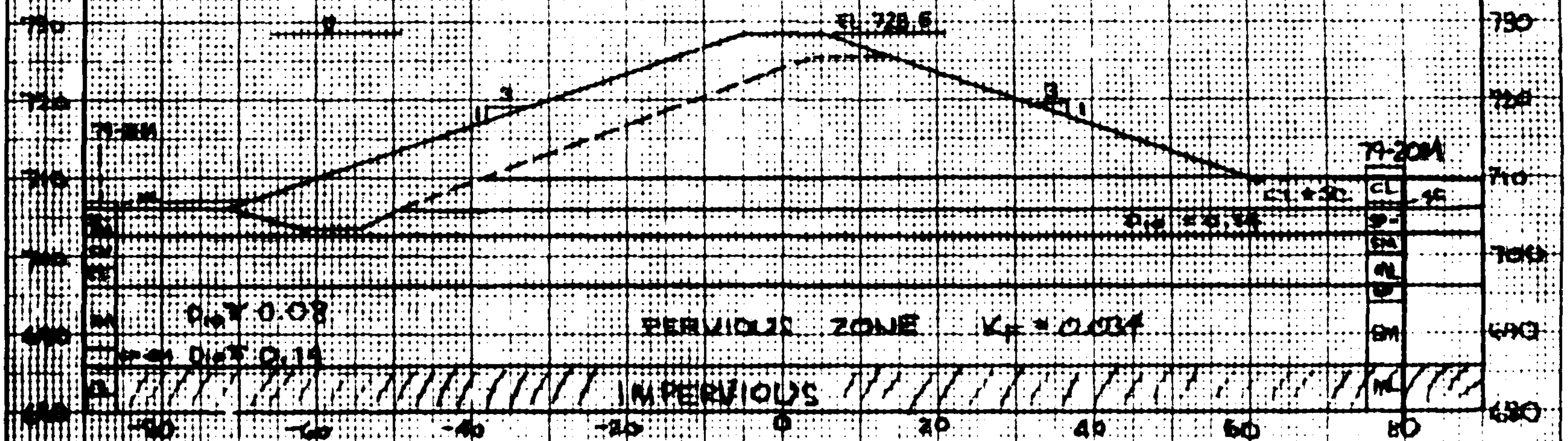
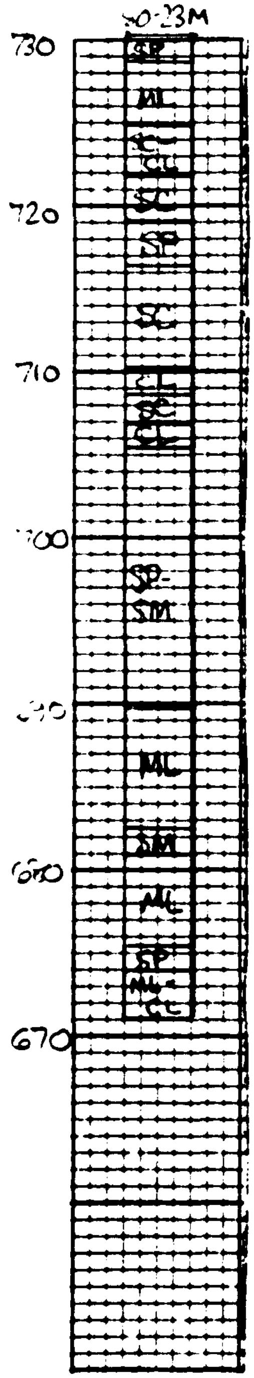


Figure 6

BORING EVALUATION SHEET | PROJECT: CHASKA - MN RIVER LEVEE

BORING NO. : 80-23M | DATE: JAN 1984



BLANKET | ELEV. TOP OF FLOOD BARRIER: 728.5

SOIL UNIT	TOP ELEV.	$K_v \times 10^4$ (1)	γ_m	Z_i	F_t (6)	Z_b	Z_t	ΣZ_b	ΣZ_t	(5) ΣWT.	ΣWT./γ_w
FILL	713.0	20	57.5	1.0	.4	.4	1.0	5.3	8.0	477.5	7.65
FILL	712.0	20	57.5	3.5	.4	1.4	3.5	4.9	7.0	420	6.73
SC	708.5	8	62.5	1.5	1	1.5	1.5	3.5	3.5	218.8	3.5
CL	707	8	62.5	2.0	1	2.0	2.0	2.0	2.0		

MINIMUM $K_v \times 10^4$ = 8 FPM

(1) SEE PAGE 265 T.M. 3-424 (2] SEE PAGE 44 T.M. 3-424
(3) G= GRADATION, P=PERMEABILITY TEST, A=ASSUMED VALUES
(4) SEE PAGE 51 T.M. 3-424 (5) WT.= $Z_t \cdot \gamma'_m$ (6) F_t=TRANS.FACTOR

PERVIOUS ZONE

SOIL UNIT	TOP ELEV.	d	D_{10}	(4) SOURCE	(3) K_h	$\Sigma K_h \cdot d$	D=Σd
SP-SM	705	3.0	0.09	G	.027	0.081	17.0
SP	702	5.5	0.14	G	.092	0.506	
SP	696.5	6.0	0.11	G	.052	0.312	
SP-SM	690.5	2.5	0.08	G	.020	0.050	
	688.0						
						0.949	

K_f= 0.056 FPM, c= 0.0155, X_3= 64.5' FT

SUMMARY COMPUTATIONS

Z_t-TOP ELEV	H	S	X_3	H_0	X	H_x	ΣWT/γ_w	F.S.	
708.5	20'	194.5	64.5	4.98	0	4.98	3.5	0.70	
713.0	15.5	126.2	79.4	4.47	0	4.47	7.65	1.71	OK
712.0	16.5	96.2	76.3	4.62	0	4.62	6.72	1.46	

v. scale
1" = 10'

PAGE 1 OF 4

NOTE: NEAR THIS SECTION IS A PUMPING STATION SPILLWAY THAT ALLOWS A DIRECT SEEPAGE ENTRANCE AT THE LEVEE TOE. THAT SECTION WILL BE COMPUTED ON PAGE 3, FOR THE SECTION SHOWN HERE.

$L_1 = 283'$ $\quad X_1 = \frac{TANH(0.0155)283}{0.0155} = 64.5'$ $\quad L_2 = 130'$ $\quad H = 20'$

$S = 64.5 + 130 = 194.5'$

$i = \frac{17}{194.5 + 64.5} = 0.066$ $\quad H_0 = 20\left(\frac{64.5}{194.5 + 64.5}\right) = 4.98'$

HOP FILL ELEV. 710.0 ; $H = 18.5'$ $\quad Z_T = 5.0$ $\quad \neq WT/\gamma_w = 5.0(62.5/62.4) = 5.0$

$Q_s = 0.066(0.056)(17)\left(7.48 \frac{GPM}{FT^3/M}\right) = 0.47$ GPM/FT. OF LEVEE

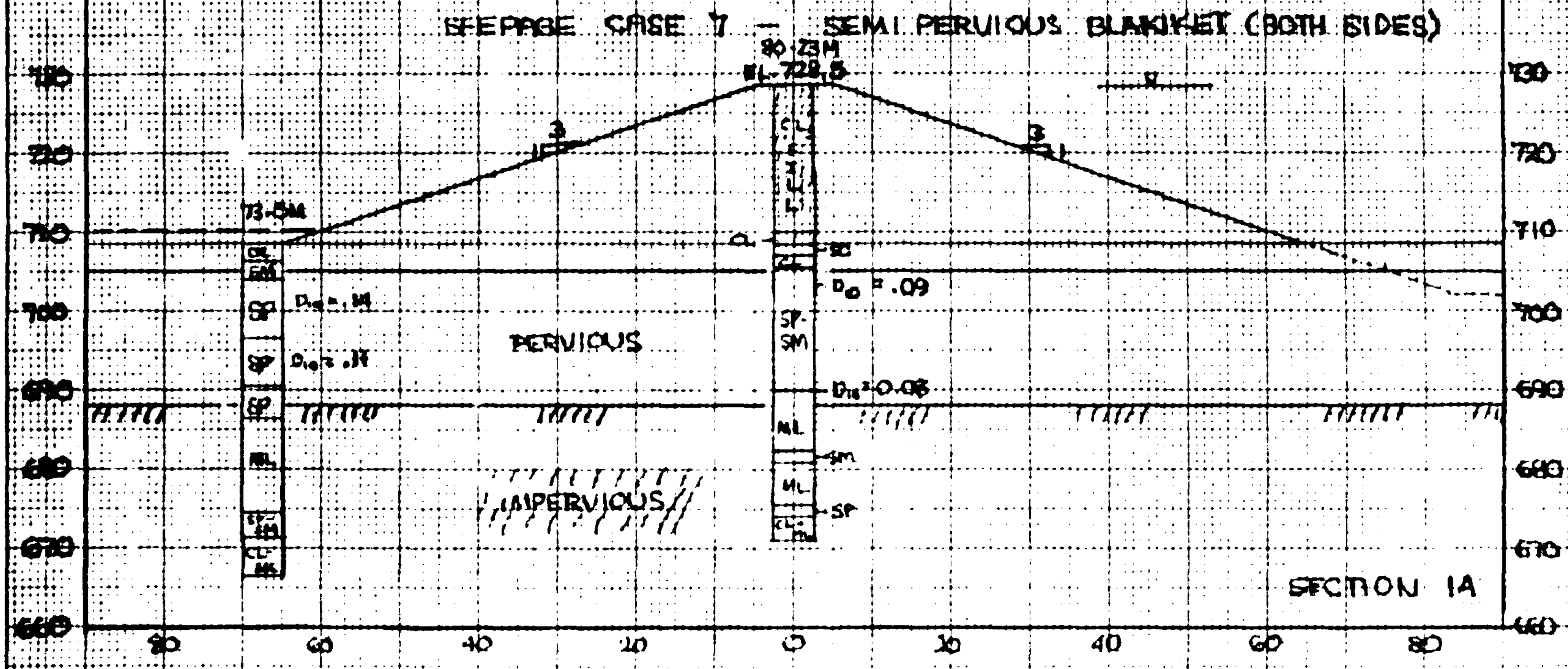


Figure 8

COMPUTATION SHEET

Date	Page
JAN. 84	3 of

Name of Office	Project
ED-GH	CHASKA

MN RIVER LEVEE - SEEPAGE AND UPLIFT

Computed by	Checked by	Approved by	Price Level
LHB			

IF THE EFFECTIVE SEEPAGE ENTRANCE IS ASSUMED TO BE THE SPILLWAY CHANNEL: THEN $L_1 = 10$ FT. USE SECTION WITH DASHED LINE TO REPRESENT THE SECT. SECTION IS STILL CASE 7 SINCE BLANKET MAT'L STILL EXISTS ON RIVERWARD SIDE

$L_1 = 10$ FT $\quad X_1 = \frac{\tanh (0.0155) 10}{0.0155} = 9.9$ FT

FOR G.S. = 708.5 : $H = 20'$ $\quad L_2 = 130'$ $\quad S = 9.9 + 130 = 139.9'$

$$H_0 = 20\left(\frac{64.5}{139.9 + 64.5}\right) = 6.31 \text{ FT.}$$

$$FS = \frac{\Sigma WT/\gamma_w}{H_0} = \frac{3.5}{6.31} = 0.55 \quad \underline{NG}$$

FOR THIS SECTION RECOMMEND THAT THE PUMPING STATION CHANNEL BE FILLED, AND A SMALLER BERM PLACED, OR DESIGN A BERM FOR THE ENTIRE AREA UNDER THESE CONDITIONS.

COMPUTING A FILL TO 712.0 $\quad C = 0.0131 \quad X_3 = 76.33'$

$S = 76.2 + 120 = 196.2$ FT $\quad X_1 = 76.24'$

COMPUTING A FILL TO 713.0 $\quad C = 0.0126 \quad X_3 = 79.4$

$S = 79.2 + 117.0 = 196.2$ FT $\quad X_1 = 79.2$

INSTEAD OF A BERM FILL BEHIND THE LEVEE TO ELEVATION 713.0 AND FILL IN SPILLWAY AND OLD CHANNEL.

COMPUTATION SHEET

Date	Page
JAN 84	4 of

Name of Office	Project
ED-GH	CHASKA - SECTION 1A

MN RIVER LEVEE - BERM DESIGN

Computed by	Checked by	Approved by	Price Level
LHB			

$R = I_o / I_1 = 0.375$ $H_0 = 4.98'$ $Z_T = 3.5'$ $H = 20'$

$S = 194.5'$ $C = 0.0155$

$A = 6 + 3SC(R+1) = 6 + 3(194.5)(0.0155)(1.375)$

$A = 18.44$

$H_A = I_1 \cdot Z_T = 0.8 \cdot 3.5 = 2.80'$

$$X_{SP} = \frac{-18.44 + \sqrt{(18.44)^2 - 24(2.375)(1 + 194.5(0.0155) - (20/2.8))}}{2(0.0155)(2.375)}$$

$X_{SP} = 58.8$ FT.

$$H_0' = 2.8\left[1 + (0.0155)(58.8) + \left(\frac{2.375}{6}\right)(0.0155(58.8))^2\right]$$

$H_0' = 6.27$ FT

THICKNESS FOR SEMI-PERVIOUS BERM : $t = \frac{6.27 - 0.3(3.5)}{1 + 0.3} = 4.02$ FT.

CONTINUE FOR SAND BERM — $X_3 = 64.5'$

$X_P = 64.5 \ \mathrm{Ln}\left(6.27/2.80\right) = 52.0$ FT

$X_S = 1/3\,(52 + 2(58.8)) = 56.5$ FT.

$$H_0' = 2.8\left[1 + 0.0155(56.5) + \left(\frac{2.375}{6}\right)(0.0155(56.5))^2\right]$$

$H_0' = 6.10$ FT.

$$t = \frac{6.10 - 3.5\left(62.5/1.6(62.4)\right)}{1 + \left(57.5/1.6(62.4)\right)} = \frac{3.91}{1.58} = 2.47'$$

SINCE RANDOM FILL WILL BE MORE IMPERVIOUS THAN PURE SAND USE THE SEMI-PERVIOUS COMPUTATIONS - WITH RANDOM FILL (+25% FOR MISC. FACTORS)

RECOMMEND: 60 FOOT WIDTH

5 FEET THICK

SLOPE 1 V ON 30 H

OR

FILL TO ELEVATION 713.0

$Q_S = 0.062(0.056)(12.5)\,7.48\left(\frac{GPM}{FT^3/day}\right) = 0.325$ GPM/FT

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1 NOV 1976

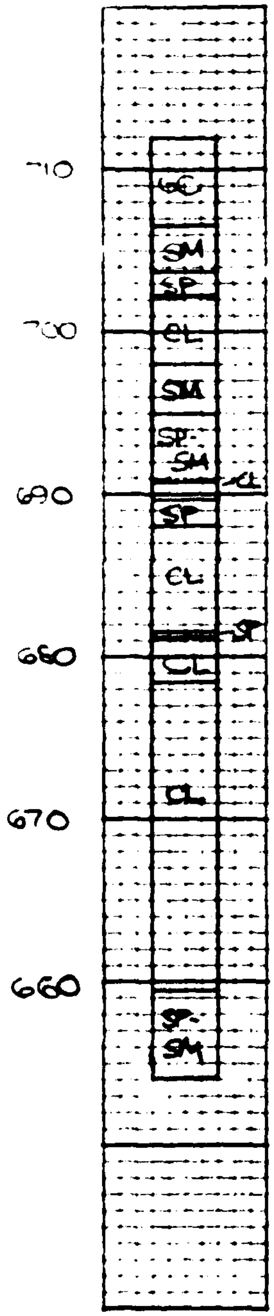
Figure 10

BORING EVALUATION SHEET

PROJECT: CHASKA - MN RIVER LEVEE

BORING NO. : 79-19M

DATE: JAN. 1984



BLANKET

ELEV. TOP OF FLOOD BARRIER: 728.5

SOIL UNIT	TOP ELEV.	$K_v \times 10^4$ (1)	γ'_m	Z_i	F_t (6)	Z_b	Z_t	ΣZ_b	ΣZ_t	Σ WT. (5)	Σ WT./γ_w
FILL	711	20	57.5	1	.5	.5		5.5	6.0	381	6.11
FILL	713	20	57.5	3	.5	1.5	3	6.5	8	496	7.95
FILL	712	20	57.5	2	.5	1.0	2	6	7.0	438.5	7.03
GC	710	10	67.5	4	1	4	4	5	5	323.5	5.18
SM	706	20	53.5	2	.5	1	1	1	1	53.5	0.86

MINIMUM $K_v \times 10^4$ = 10 FPM

(1) SEE PAGE 265 T.M. 3-424 (2) SEE PAGE 44 T.M. 3-424
(3) G= GRADATION, P=PERMEABILITY TEST, A=ASSUMED VALUES
(4) SEE PAGE 51 T.M. 3-424 (5) WT.= $Z_t \cdot \gamma'_m$ (6) F_t=TRANS.FACTOR

PERVIOUS ZONE

SOIL UNIT	TOP ELEV.	d	D_{10}	SOURCE (4)	K_h (3)	$\Sigma K_h \cdot d$	D=Σd
SP	704	2	.18	A	.16	0.32	2
CL	702	2	—	—	—	—	2
SM	698	3	—	—	—	—	2
SP-SM	695	4.5	.08	G	.02	0.09	6.5
CL	690.5	1.0	—	—	—	—	6.5
SP	689.5	1.5	.08	A	.02	0.03	8.0
	688						
						.44	

K_f= 0.055 FPM, c= 0.0213, X_3= 46.9 FT

SUMMARY COMPUTATIONS

Z_t-TOP ELEV	H	S	X_3	H_0	X	H_x	ΣWT/γ_w	F.S.
710	18.5	180.9	46.9	3.80	0	—	5.18	1.36
711	17.5	183.2	49.2	3.70	0	—	6.11	1.65 *
713	15.5	187.5	53.5	3.44	0	—	7.95	2.31

* FILL ENTIRE AREA TO 711.0 TO SATISFY UPLIFT CONDITIONS AS A MINIMUM

v. scale
1" = 10'

PAGE 1 OF 2

Figure 11

$L_1 = 341$ FT. $\quad X_1 = \dfrac{\tanh(0.0213)(341)}{0.0213} = 46.9$ FT.

$L_2 = 134$ FT $\quad S = 46.9 + 134 = 180.9$ FT.

$h_0 = 18.5 \left[\dfrac{46.9}{180.9 + 46.9}\right] = 3.80$

$i = \dfrac{8.0}{180.9 + 46.9} = 0.035$

EXISTING $\quad Q_s = 0.035(0.065)(10.5)(7.48) = 0.223$ GPM/FT OF LEVEE

(7/11) DESIGN $\quad Q_s = 0.035(0.065)(12.5)(7.48) = 0.17$ GPM/FT

SEEPAGE CASE 7 - SEMI-PERVIOUS BLANKET (BOTH SIDES)

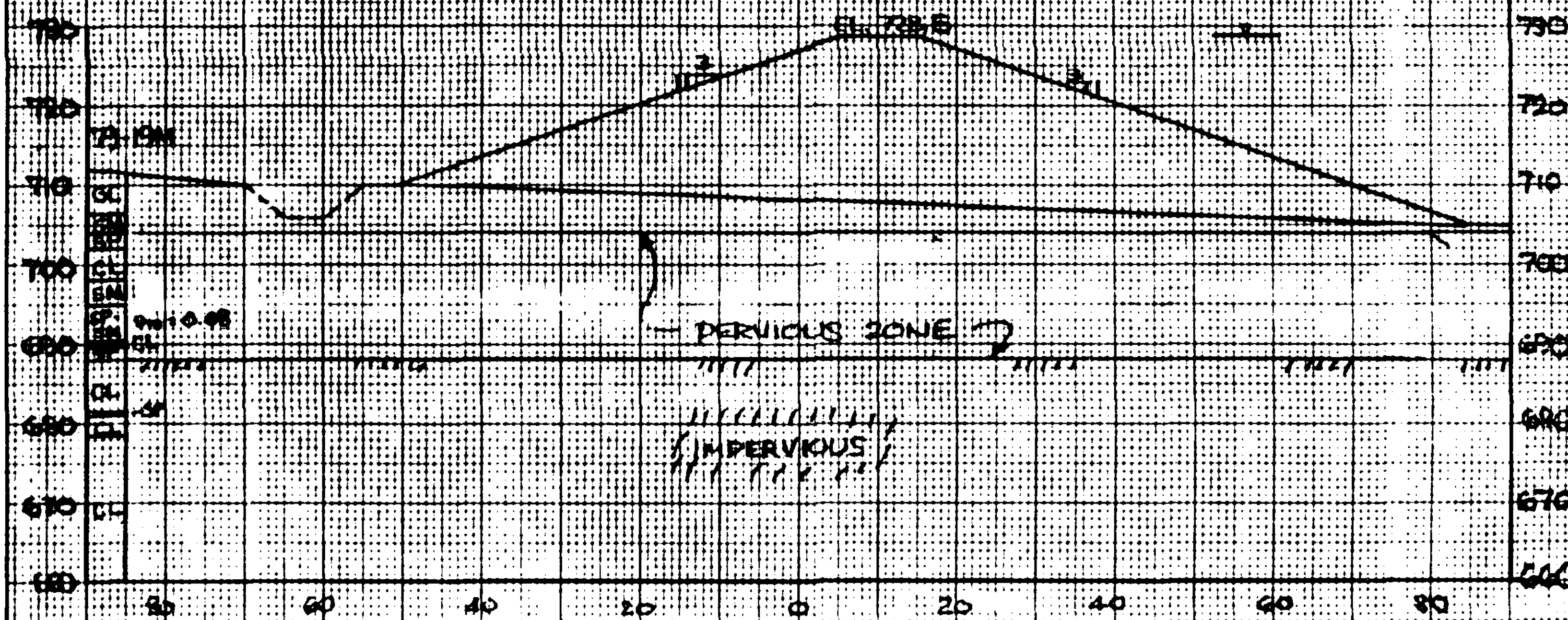


Figure 12

BORING EVALUATION SHEET

PROJECT: CHASKA- MN RIVER LEVEE

BORING NO. : 73-1M

DATE: JAN 1984

FOR BORING - SEE Pg 2

BLANKET

ELEV. TOP OF FLOOD BARRIER: 728.5

SOIL UNIT	TOP ELEV.	$K_v \times 10^4$ (1)	γ_m	Z_i	F_t (6)	Z_b	Z_t	ΣZ_b	ΣZ_t	Σ WT. (5)	$\Sigma WT./\gamma_w$
SM	714.8	20	57.5	3.3	.3	0.99	9.8	7.5	9.8	596.0	9.55
CL	711.5	6	62.5	6.5	1.0	6.5	6.5	6.5	6.5	406.2	
FILL	714	20	57.5	2.0	.4	0.8	2.0	5.4	9.0	532.5	8.53
FILL	712	20	57.5	2.0	.4	0.8	2.0	4.6	7.0	417.5	6.69
SM	710	20	57.5	2.0	.4	0.8	2.0	3.8	5.0	302.5	4.85
CL	708	8	62.5	3.0	1.0	3.0	3.0	3.0	3.0	87.5	

MINIMUM $K_v \times 10^4$ = 8 FPM

(1) SEE PAGE 265 T.M. 3-424 (2) SEE PAGE 44 T.M. 3-424
(3) G= GRADATION, P=PERMEABILITY TEST, A=ASSUMED VALUES
(4) SEE PAGE 51 T.M. 3-424 (5) WT.= $Z_t * \gamma'_m$ (6) F_t=TRANS.FACTOR

PERVIOUS ZONE

SOIL UNIT	TOP ELEV.	d	D_{10}	(4) SOURCE	(3) K_h	$\Sigma K_h * d$	$D = \Sigma d$
SP-SM	705	10.7	0.08	G	0.02	0.214	10.7
SM	694.3	—	—	—	—	—	10.7
SP-SM	690.5	2.5	0.10	G	0.038	0.095	13.2
SP	688.0	6.0	0.14	G	0.092	0.552	19.2
ML	682.0	—	—	—	—	—	19.2
SP	676.6	4.1	0.14	A	0.092	0.377	23.3
SW-SM	672.5	7.3	0.095	G	0.033	0.241	30.6
CL	665.2	—	—	—	—	—	30.6
SW-SM	664.0	19.5	0.12	G	0.066	1.287	50.1
SP-SM	644.5	18.5	0.17	G	0.14	2.590	68.6
GP	626.0	19.0	0.21	G	0.22	4.180	87.6
SP	607.0	9.0	0.19	G	0.18	1.620	96.6
SP	598.0	22.0	0.12	G	0.066	1.452	118.6
a-CH	576.0					12.608	

K_f= 0.106 FPM, c= 0.0041, X_3= 244.4 FT

SUMMARY COMPUTATIONS

Z_t-TOP ELEV.	H	S	X_3	H_0	X	H_x	$\Sigma WT./\gamma_w$	F.S.
710	18.5	159.9	244.4	11.18'	0	11.18	4.85	0.43
712	16.5	159.9	268.9	10.35	0	10.35	6.69	0.65
714	14.5	159.9	291.3	9.36	0	9.36	8.53	0.91
714.8	18.5	159.9	244.4	11.18	200	4.92	9.55	1.94

* THIS SECTION WILL REQUIRE A RBPM

v. scale
1" = ______

Figure 13

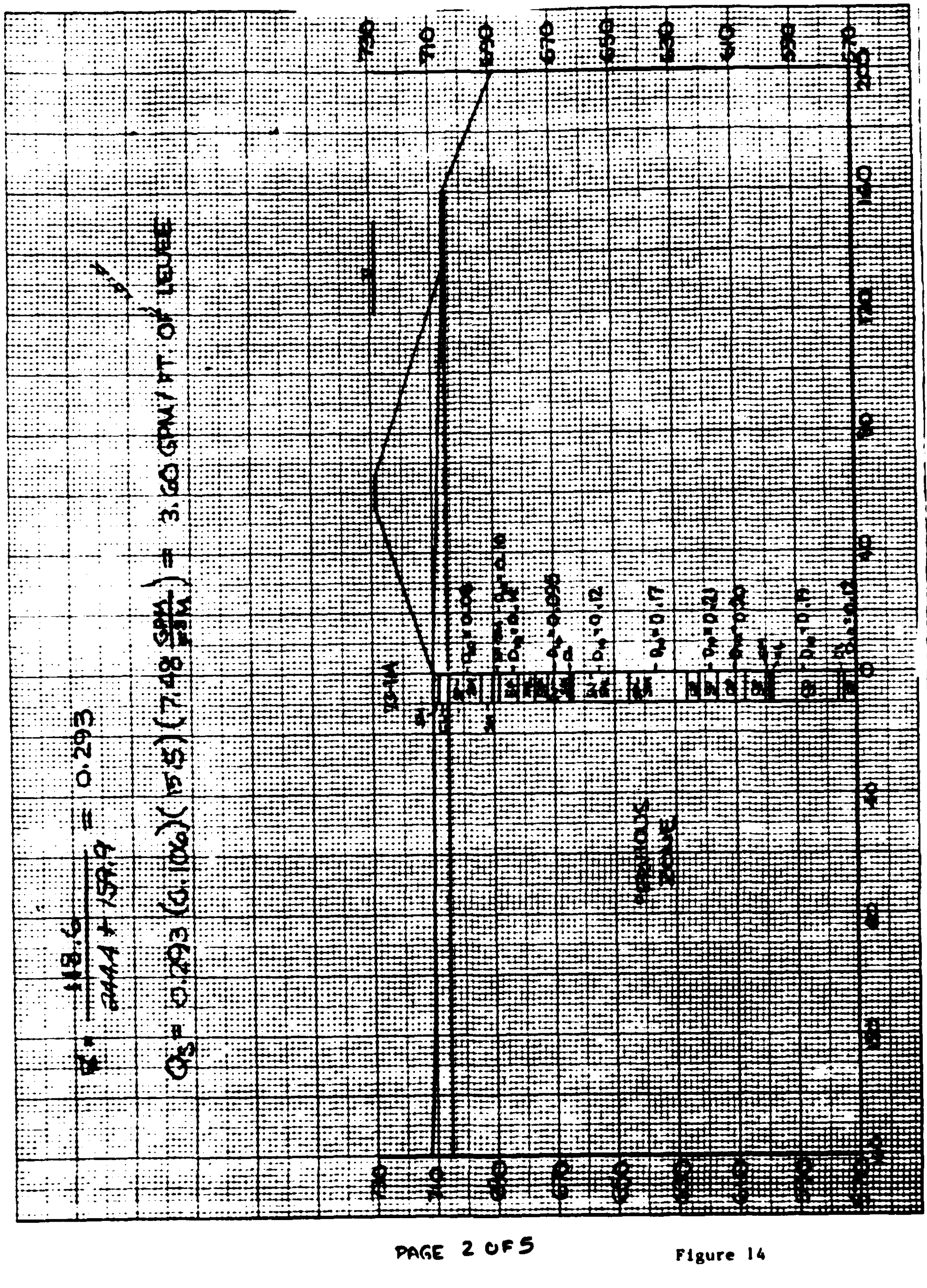


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Figure 14

COMPUTATION SHEET

Date	Page
JAN 84	3 of 5

Name of Office	Project
ED-GH	CHASKA - MN RIVER LEVEE

SEEPAGE AND UPLIFT

Computed by	Checked by	Approved by	Price Level
LHB			

$Z_T = 710.0$

$L_2 = 135'$ $L_1 = 25'$ $L_3 = \infty$ $X_3 = 244.4$ FT.

$X_1 = \frac{\tanh(0.0041(25))}{0.0041} = 24.9$ FT. $H_{200} =$

$S = 135' + 24.9' = 159.9'$ $H_0 = 18.5\left[\frac{244.4}{244.4 + 159.9}\right] = 11.18$

$Z_T = 712.0$

$L_2 = 135'$ $L_1 = 25'$ $C = \sqrt{\frac{0.0008}{0.106(118.6)(4.6)}} = 0.0037$

$X_3 = 268.9'$ $X_1 = \frac{\tanh(0.0037(25))}{0.0037} = 24.9'$

$S = 159.9'$

$H_0 = 16.5\left[\frac{268.9}{268.9 + 159.9}\right] = 10.35'$

$Z_T = 714.0$

$C = \sqrt{\frac{0.0008}{0.106(118.6)(5.4)}} = 0.0034$

$X_3 = 291.3'$ $X_1 = 24.9'$

$S = 159.9'$

$H_0 = 14.5\left[\frac{291.3}{291.3 + 159.9}\right] = 9.36'$

BERM COMPUTATIONS WILL BE MADE USING THE 710.0 EXISTING GROUND SURFACE AND THE 712.0 FILL ELEVATION

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1 NOV 1976

Figure 15

COMPUTATION SHEET

Date JAN 84	Page 4 of 5

Name of Office ED-GH	Project CHASKA		
BERM DESIGN - SECTION 2A			
Computed by LHQ	Checked by	Approved by	Price Level

Z_T TOP ELEV. = 710.0   C = 0.0041 X_3 = 244.4'

I_o = 0.3 I_1 = 0.8 H_o = 11.18' X_4 = 24.9'

S = 159.9' L_3 = 135'

$R = .3/.8 = 0.375$ $H_A = .8(5) = 4.0'$

$A = 6 + 3(159.9)(0.0041)(1.375) = 8.70$

$$X_{SP} = \frac{-8.7 + \sqrt{(8.7)^2 - 24(2.375)(1 + (159.9(0.0041) - 18.5/4.0)}}{2(0.0041)(2.375)}$$

$X_{SP} = 356.9'$

$$H_o' = 4.0\left[1 + (0.0041(356.9)) + 2.375/6\,(0.0041(356.9))^2\right]$$

$H_o' = 13.24$ FT

$X_p = 244.4 \ Ln\left(13.24/4.0\right) = 292.5$ FT

$X_S = 1/3\,(292.5 + 2(356.9)) = 335.4$ FT.

$$H_o' = 4.0\left[1 + (0.0041(335.4)) + 2.375/6\,(0.0041(335.4))^2\right] =$$

$H_o' = 12.49'$

$$t = \frac{12.49' - 5.0\left(\frac{60.0}{1.6(62.4)}\right)}{1 + \left(\frac{57.5}{1.6(62.4)}\right)} = \frac{9.49}{1.58} = 6.0 \text{ FT.}$$

FOR Z_T TOP ELEVATION OF 710.0 RECOMMEND A BERM WITH:

TOP WIDTH = 335 FT.
SLOPED AT 1V ON 75H
THICKNESS = 7.5' (INCREASED 25%)

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1 NOV 1976

Figure 16

COMPUTATION SHEET

Date JAN 84	Page 5 of 5		
Name of Office ED-GH	Project CHASKA- MN RIVER LEVEE		
BERM DESIGN - SECTION 2A			
Computed by LHB	Checked by	Approved by	Price Level

Z_T TOP ELEVATION = 712.0 $\qquad c = 0.0037 \qquad X_3 = 268.9'$

$S = 159.9' \qquad X_1 = 24.9'$

$I_o = 0.3 \qquad I_1 = 0.8 \qquad H_o = 10.35' \qquad L_2 = 135'$

$R = {}^{0.3}/_{0.8} = 0.375 \qquad H_A = 0.8(7.0) = 5.6'$

$$A = 6 + 3(159.9)\,0.0037(1.375) = 8.44$$

$$X_{SP} = \frac{-8.44 + \sqrt{(8.44)^2 - 24(2.375)(1 + 159.9(0.0037)) - {}^{16.5}/_{5.6})}}{2(0.0037)(2.375)}$$

$X_{SP} = 213.0$ FT.

$$H_o' = 5.6\left[1 + (0.0037)(213)) + {}^{2.375}/_{6}\,(0.0037(213))^2\right]$$

$H_o' = 11.39'$

$$X_D = 268.9\ \text{LN}\left({}^{11.39}/_{5.6}\right) = 190.9'$$

$$X_S = {}^{1}/_{3}(190.9 + 2(213)) = 205.6' \quad (\text{USE } 210')$$

$$H_o' = 5.6\left[1 + 0.0037(210) + {}^{2.375}/_{6}\,(0.0037(210))^2\right] = 11.29'$$

$$t = \frac{11.29 - 7.0\left(\frac{60.0}{1.6(62.4)}\right)}{1 + \left(\frac{57.5}{1.6(62.4)}\right)} = \frac{7.08}{1.58} = 4.48'$$

FOR Z_T TOP ELEVATION OF 712.0 RECOMMEND FILL TO 712.0 AND A BERM WITH:

TOP WIDTH = 210'
SLOPED AT 1V ON 75H
THICKNESS = 5.5' (INCREASED 25%)

NCS FORM 34
1 NOV 1976

Figure 17

COMPUTATION SHEET

Date: FEB 84	Page: 6 of
Name of Office: ED-GH	Project: HASKA - MN RIVER LEVEE
UPLIFT ASSUMING A SEEPAGE BLOCK	
Computed by: LHB	Checked by:
Approved by:	Price Level:

COMPUTATIONS ASSUMING A SEEPAGE BLOCK EXISTS

AT $X = 335$ FT — $H = 18.5'$

$K_B = 0.0008$ FPM $K_F = 0.106$ FPM $C = 0.0041$

$X_3 = 1/C\,(\tanh C(L_3))$ $L_3 = 199$ FT $(335 - 136)$

$X_3 = 1/0.0041\,(\tanh(0.0041(199))) = 362.5$ FT.

$X_1 = 24.9$ FT. $L_2 = 136$ $S = 136 + 24.9 = 160.9$ FT

$$H_o = 18.5\left[\frac{362.5}{362.5 + 160.9}\right] = 12.81 \text{ FT.}$$

$$FS = \frac{Z\gamma'/\gamma_w}{H_o} = \frac{4.85}{12.81} = 0.38$$ $\Delta H_o = 12.81 - 11.18 = 1.63'$

— USE THIS HEAD TO DESIGN FOR RELIEF WELLS —

DESIGN PARAMETERS —

D = 118.6 FT.	FK = 0.106 FPM	X_3 = 362.5	S = 160.9 FT
H = 18.5 FT.	WHT = −4	RL = [illegible]4	DIA. = 12 IN.
RW = 0.8 FT	FREE = 3.0	WDI = 0	SAFE = 1
F = 1.7	U = 0.0		

LAYER	ZT (I)	GAM(I)
1	2	120 PCF
2	3	125 PCF

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1 NOV 1976

Figure 18

[illegible] MINNESOTA - MN RIVER LEVEE
RELIEF WELL DESIGN FOR SECTION 6
[illegible] 6 INCH DIA FEB 1984

INPUT DATA

D	FK	X3	S	H	WHT	RL
[illegible] 600	0 106	362 500	160 900	18 500	-1 000	4 500

DIA	RW	FREE	WDI	SAFE	F	U
[illegible] 000	0 800	3 000	0 000	1 000	1 700	0 000

LAYER	ZT(I)	GAM(I)
1	2 0	120 00
2	3 0	125 00

PROGRAM COMMENTS

SCREEN LENGTH 118 [illegible]00

OUTPUT DATA

[illegible]D	SP	QW	V	HW	HAV	HAV1	TAV	TAV1
0 4[illegible]	34 714	292	1 863	-0 765	2 853	3 622	1 168	1 168
[illegible]	45 038	379	2 418	-0 677	2 856	3 534	0 878	0 878
0 60	52 352	443	2 832	-0 594	2 775	3 369	0 714	0 714
[illegible]	55 924	484	3 069	-0 529	2 562	3 091	0 601	0 601
0 80	59 098	519	3 316	-0 458	2 402	2 860	0 518	0 518
0 [illegible]0	61 971	550	3 512	-0 385	2 278	2 663	0 455	0 455
1 00	64 348	577	3 687	-0 309	2 181	2 490	0 406	0 406

[illegible]D	TM1	QUEW	QSW	QS	R	HAV B	HM1	TM
0 40	0 879	7 143	0 588	7 734	112	2 267	0 000	0 000
0 [illegible]0	0 808	7 152	0 586	7 738	112	2 260	0 000	0 000
0 [illegible]	0 732	7 213	0 567	7 782	110	2 184	3 450	0 732
0 [illegible]	0 658	7 374	0 518	7 892	108	1 996	3 385	0 658
0 [illegible]0	0 600	[illegible] 495	0 481	7 976	106	1 853	3 315	0 600
[illegible]	0 554	7 590	0 452	8 041	104	1 741	3 242	0 554
1 00	0 516	7 664	0 429	8 093	103	1 653	3 165	0 516

RUN COMPLETE

Figure 19

PAGE 1

CHASKA MINNESOTA - MN RIVER LEVEE
RELIEF WELL DESIGN FOR SECTION 6
CHB 12 INCH DIA FEB 1984

INPUT DATA

D	FK	X3	S	H	WHT	HL
118 600	0 106	352 500	160 900	18 500	-1 000	4 500

DIA	RW	FREE	WD1	SAFE	F	U
12 000	0 800	3 000	0 000	1 000	1 700	0 000

LAYER	ZT(I)	GAM(I)
1	2 0	120 00
2	3 0	125 00

PROGRAM COMMENTS

SCREEN LENGTH- 118 600

OUTPUT DATA

WD	SP	QW	V	HW	HAV	HAV1	TAV	TAV1
0 40	35 102	303	0 861	-0 890	2 856	3 746	1 161	1 162
0 50	47 416	398	1 131	-0 870	2 856	3 726	0 879	0 879
0 60	55 064	469	1 330	-0 855	2 730	3 585	0 720	0 720
0 70	59 556	518	1 470	-0 845	2 508	3 353	0 609	0 609
0 80	63 784	564	1 600	-0 833	2 339	3 172	0 529	0 529
0 90	67 757	606	1 721	-0 820	2 206	3 026	0 469	0 469
1 00	71 501	646	1 835	-0 804	2 100	2 904	0 423	0 423

WD	TM1	QUEW	QSW	QS	R	HAV B	HM1	TM
0 40	0 894	7 139	0 590	7 729	113	2 274	0 000	0 000
0 50	0 824	7 141	0 590	7 730	113	2 273	0 000	0 000
0 60	0 745	7 232	0 561	7 794	112	2 164	3 712	0 745
0 70	0 672	7 393	0 512	7 905	109	1 974	3 702	0 672
0 80	0 615	7 515	0 474	7 990	107	1 829	3 690	0 615
0 90	0 570	7 612	0 445	8 056	106	1 715	3 676	0 570
1 00	0 533	7 689	0 421	8 110	105	1 623	3 660	0 533

RUN COMPLETE
EOF
E>

Figure 20

BORING EVALUATION SHEET

PROJECT: CHASKA - MN RIVER LEVEE

BORING NO. : 83-60M, 79-14M

DATE: JAN 1984

BLANKET

ELEV. TOP OF FLOOD BARRIER: 728

SOIL UNIT	TOP ELEV.	(1) $K_v x10^4$	γ_m	z_i	(6) F_t	z_b	z_t	Σz_b	Σz_t	(5) ΣWT.	ΣWT. / γ_w
GC/SC	713.0	20	67.5	3.0	1.0	3.0	3.0	6.5	6.5	438.8	7.03
FILL	710.0	20	67.5	3.5	1.0	3.5	3.5	3.5	3.5	236.3	3.78

MINIMUM $K_v \times 10^4$ = 20 **FPM**

(1) SEE PAGE 265 T.M. 3-424 (2) SEE PAGE 44 T.M. 3-424
(3) G= GRADATION, P=PERMEABILITY TEST, A=ASSUMED VALUES
(4) SEE PAGE 51 T.M. 3-424 (5) WT.= $z_t * \gamma'_m$ (6) F_t=TRANS.FACTOR

PERVIOUS ZONE

SOIL UNIT	TOP ELEV.	d	D_{10}	(4) SOURCE	(3) K_h	ΣK_h*d	D=Σd
SP-SM	706.5	7.4	0.08	G	0.02	0.148	7.4
SP-SM	699.1	4.3	0.10	G	0.038	0.163	11.7
SP-SM	694.8	10.1	0.12	G	0.066	0.667	21.8
SP-SM	684.7	9.3	0.15	G	0.105	0.977	31.1
SP-SM	675.4	12.4	0.14	G	0.092	1.141	43.5
SW-SM	~~663~~ 661	16.5	0.12	GA	0.066	1.089	60.0
SP-SM	644.5	18.5	0.17	GA	0.140	2.590	78.5
GP	626	19.0	0.21	GA	0.220	4.180	97.5
SP	607	9.0	0.19	GA	0.180	1.620	106.5
SP	598	22	0.12	GA	0.066	1.452	128.5
CL-CH	576						
						14.027	

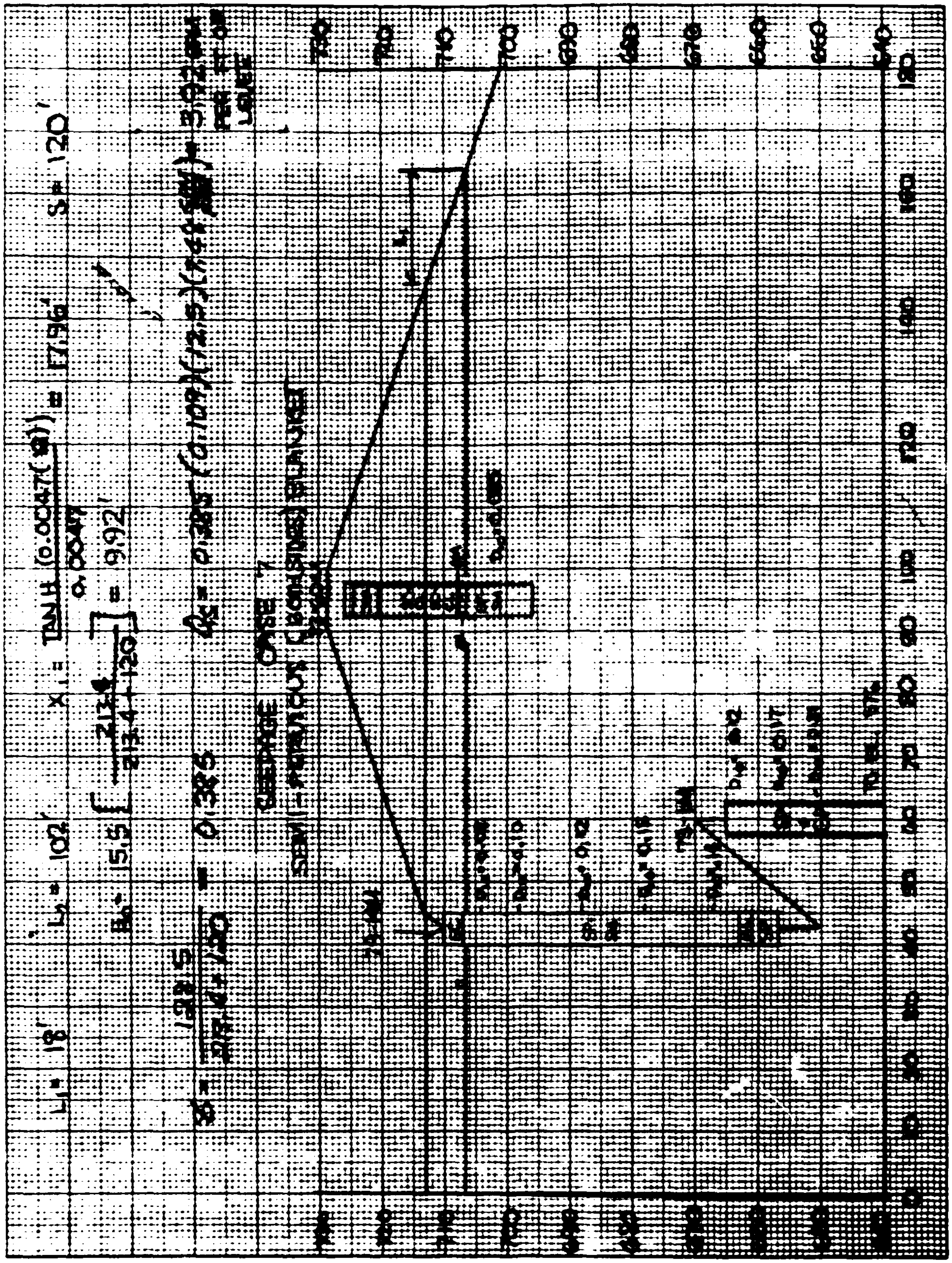
K_f= 0.109 FPM, c= 0.0047 , X_3= 213.4' FT

SUMMARY COMPUTATIONS

Z_t-TOP ELEV	H	S	X_3	H_0	X	H_x	ΣWT / γ_w	F.S.
713.0	15.5	120'	213.4'	9.92'	0	9.92'	7.03	0.71

v. scale
1" = ______

Figure 41



PAGE 2 OF 3

Figure 22

COMPUTATION SHEET

Date JAN 84	Page 3 of	
Name of Office ED-GH	Project CHASKA - MN RIVER LEVEE	

BERM DESIGN - SECTION 3

Computed by	Checked by	Approved by	Price Level
LHB			

FT TOP ELEVATION = 713.0

$I_o = 0.3$ $I_1 = 0.8$ $C = 0.0047$ $H_A = .8(6.5) = 5.2'$

$H = 15.5'$ $H_o = 9.92'$

$R = 0.3/0.8 = 0.375$ $X_3 = 213.4'$ $X_1 = 18'$

$S = 120'$ $Z_T = 6.5$

$$A = 6 + 3(0.0047)(120)(1.375) = 8.33$$

$$X_{SP} = \frac{-8.33 + \sqrt{(8.33)^2 - 24(2.375)(1 + 120(0.0047) - 15.5/5.2)}}{2(2.375)(0.0047)}$$

$X_{SP} = 175.7$ FT

$$H_o' = 5.2\left[1 + 0.0047(175.7) + 2.375/6\,(0.0047(175.7))^2\right]$$

$H_o' = 10.9'$

$$X_P = 213.4 \; L_N(10.9/5.2) = 157.9 \text{ FT}$$

$$X_S = 1/3\left[157.9 + 2(175.7)\right] = 169.8' \quad \text{USE } X_S = 170'$$

$$H_o' = 5.2\left[1 + 0.0047(170) + 2.375/6\,(0.0047(170))^2\right]$$

$H_o' = 10.67'$

$$t = \frac{10.67 - 6.5\left(\frac{67.5}{1.6(62.4)}\right)}{1 + \left(\frac{57.5}{1.6(62.4)}\right)} = \frac{6.28}{1.58} = 3.97'$$

RECOMMEND - FILL TO ELEVATION 713.0
CONSTRUCT BERM TO FOLLOW DIMENSIONS -

THICKNESS - 5.0'
WIDTH - 170'
SLOPE - 1V ON 50' H

THIS SECTION IS NOT AFFECTED BY THE ASSUMED SEEPAGE BLOCK.

NCS FORM 34
1 NOV 1976

PAGE 1

CHASKA MINNESOTA - MN RIVER LEVEE
RELIEF WELL DESIGN FOR SECTION 7
LRB 6 INCH DIA FEB 1984

INPUT DATA
****

D	FK	XJ	S	H	WHT	RL
125 500	0 109	213 400	120 000	15 500	-4 000	4 500

DIA	RW	FREE	WDI	SAFE	F	U
6 000	0 800	3 000	0 000	1 000	1 700	0 000

LAYER	ZT(I)	GAM(I)
1	6 5	125 00

PROGRAM COMMENTS
****
SCREEN LENGTH- 128 500

OUTPUT DATA
****

WD	SP	QW	V	HW	HAV	HAV1	TAV	TAV1
0 40	75 247	625	3 989	-3 279	3 836	7 115	1 193	1 193
0 50	82 703	725	4 629	-3 092	3 496	6 588	0 952	0 952
0 60	88 726	808	5 163	-2 888	3 241	6 129	0 794	0 794
0 70	93 892	879	5 613	-2 672	3 059	5 731	0 683	0 683
0 80	98 385	939	5 996	-2 449	2 923	5 375	0 600	0 600
0 90	102 162	988	6 313	-2 225	2 828	5 053	0 536	0 536
1 00	105 303	1029	6 573	-2 003	2 754	4 760	0 484	0 484

WD	TM1	QUEW	QSW	QS	R	HAV E	HM1	TM
0 40	1 187	7 185	1 342	8 527	128	2 733	0 000	0 000
0 50	1 001	7 599	1 193	8 792	120	2 430	6 928	1 001
0 60	0 872	7 914	1 080	8 994	114	2 199	6 724	0 871
0 70	0 776	8 146	0 996	9 142	109	2 029	6 508	0 776
0 80	0 702	8 315	0 935	9 250	106	1 905	6 285	0 701
0 90	0 643	8 450	0 887	9 336	103	1 806	6 061	0 642
1 00	0 594	8 554	0 849	9 403	101	1 729	5 841	0 595

RUN COMPLETE
EOT

DIRECT FROM CODEX BOOK CO. NORWOOD MASS.
PRINTED IN U.S.A.
Graph Paper

Figure 24

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????????????????????????????????????????????????????????????????

  PAGE   1

CHASKA MINNESOTA - MN RIVER LEVEL
SECTION 7 RELIEF WELL DESIGN
LHB     12 INCH DIA       FEB 1984
```

INPUT DATA
****

D	FK	X3	S	H	WHT	RL
128 500	0 109	213 400	120 000	15 500	-4 000	4 500

DIA	RW	FREE	WD1	SAFE	T	U
12 000	0 800	3 000	0 000	1 000	1 700	0 000

LAYER	ZT(I)	GAM(I)
*****	*****	******
1	6 5	125 00

PROGRAM COMMENTS
****
SCREEN LENGTH 128 500

OUTPUT DATA
****

WD	SP	QW	V	HW	HAV	HAV1	TAV	TAV1
0 40	78 761	658	1 867	-3 728	3 799	7 528	1 199	1 199
0 50	87 221	775	2 200	-3 698	3 407	7 105	0 960	0 960
0 60	95 173	882	2 504	-3 659	3 126	6 785	0 806	0 806
0 70	102 645	981	2 783	-3 613	2 917	6 530	0 698	0 698
0 80	109 677	1071	3 041	-3 561	2 759	6 320	0 618	0 618
0 90	116 295	1156	3 280	-3 504	2 637	6 141	0 557	0 557
1 00	122 374	1232	3 496	-3 443	2 540	5 984	0 509	0 508

WD	TM1	QULW	QSW	QS	R	HAV B	HM1	TM
0 40	1 205	7 205	1 335	8 540	130	2 719	7 564	1 205
0 50	1 018	7 669	1 168	8 837	122	2 378	7 533	1 018
0 60	0 890	8 003	1 047	9 051	117	2 133	7 494	0 890
0 70	0 796	8 253	0 958	9 210	113	1 951	7 449	0 796
0 80	0 723	8 443	0 889	9 332	110	1 811	7 397	0 723
0 90	0 666	8 592	0 835	9 428	108	1 702	7 340	0 665
1 00	0 618	8 716	0 791	9 507	106	1 611	7 279	0 619

```
  RUN COMPLETE
:UT
:>
```

Figure 25

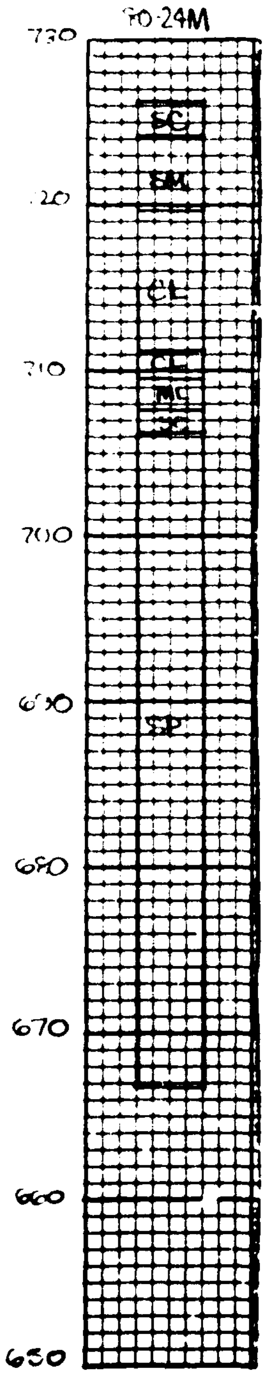
BORING EVALUATION SHEET

PROJECT: CHASKA, MN RIVER LEVEE

BORING NO. : 80-24M, 79-13M

DATE: JAN 84

SECTION 4



BLANKET

ELEV. TOP OF FLOOD BARRIER: 728.0

SOIL UNIT	TOP ELEV.	$K_v \times 10^4$ (1)	γ_m	z_i	F_t (6)	z_b	z_t	Σz_b	Σz_t	ΣWT. (5)	ΣWT./γ_w
FILL	713.0	20	57.5	2.8	.4	1.12	2.8	5.22	6.9	417.3	6.69
SC	710.2	8	62.5	4.1	1.0	4.1	4.1	4.1	4.1	256.3	4.11

MINIMUM $K_v \times 10^4$ = 8 FPM

(1) SEE PAGE 265 T.M. 3-424 (2) SEE PAGE 44 T.M. 3-424
(3) G= GRADATION, P=PERMEABILITY TEST, A=ASSUMED VALUES
(4) SEE PAGE 51 T.M. 3-424 (5) WT.= $Z_t \cdot \gamma'_m$ (6) F_t=TRANS.FACTOR

PERVIOUS ZONE

SOIL UNIT	TOP ELEV.	d	D_{10}	(4) SOURCE	(3) K_h	$\Sigma K_h \cdot d$	D= Σd
SP-SM	706.1	8	0.18	G	.16	1.280	8
SP-SM	698.1	3	0.09	G	.027	0.081	11
SP-SM	695.1	15.1	0.10	G	.038	0.574	26.1
SP-SM	680	9.5	0.12	G	.066	0.627	35.6
CL	670.5	—	—	—	—	—	35.6
SP	669.3	6.8	0.12	A	.066	0.449	42.4
SP-SM	662.5	2.3	0.072	G	.016	0.037	44.7
SW-SM	660.2	15.7	0.12	A	.066	1.036	60.4
SP-SM	644.5	18.5	0.17	A	.14	2.590	78.9
SP	626	19	0.21	A	.22	4.180	97.9
SP	607	9	0.19	A	.18	1.620	106.9
SP	598	22	0.12	A	.066	1.452	128.9
CL-CH	576					13.926	

K_f= 0.108 FPM, c= 0.0087, X_3= 267.1 FT

SUMMARY COMPUTATIONS

Z_t-TOP ELEV	H	S	X_3	H_0	X	H_x	ΣWT./γ_w	F.S.
710.2	17.8	183.4'	267.1'	10.55	0	10.55	4.11	0.39
713.0	15.0	183.4'	301.4'	9.33	0	9.33	6.69	0.72

v. scale
1" = 10'

PAGE 1 OF 3

Figure 26

$$H_0 = 128\left[\frac{267.1}{267.1 + 183.4}\right] = 10.55'$$

$$X_L = 0.43(128.9) = 55.4'$$

$$S = 128 + 55.4 = 183.4'$$

$$Y = \frac{128.9}{183.4 + 267.1} = 0.286$$

$$Q_S = 0.286(0.108)(14.8)\left(748\ \frac{GPM}{FPM}\right) = 3.42\ \text{GPM/FT OF LEVEE}$$

SEEPAGE CASE G – SEMI-PERVIOUS BLANKET LANDSIDE ONLY

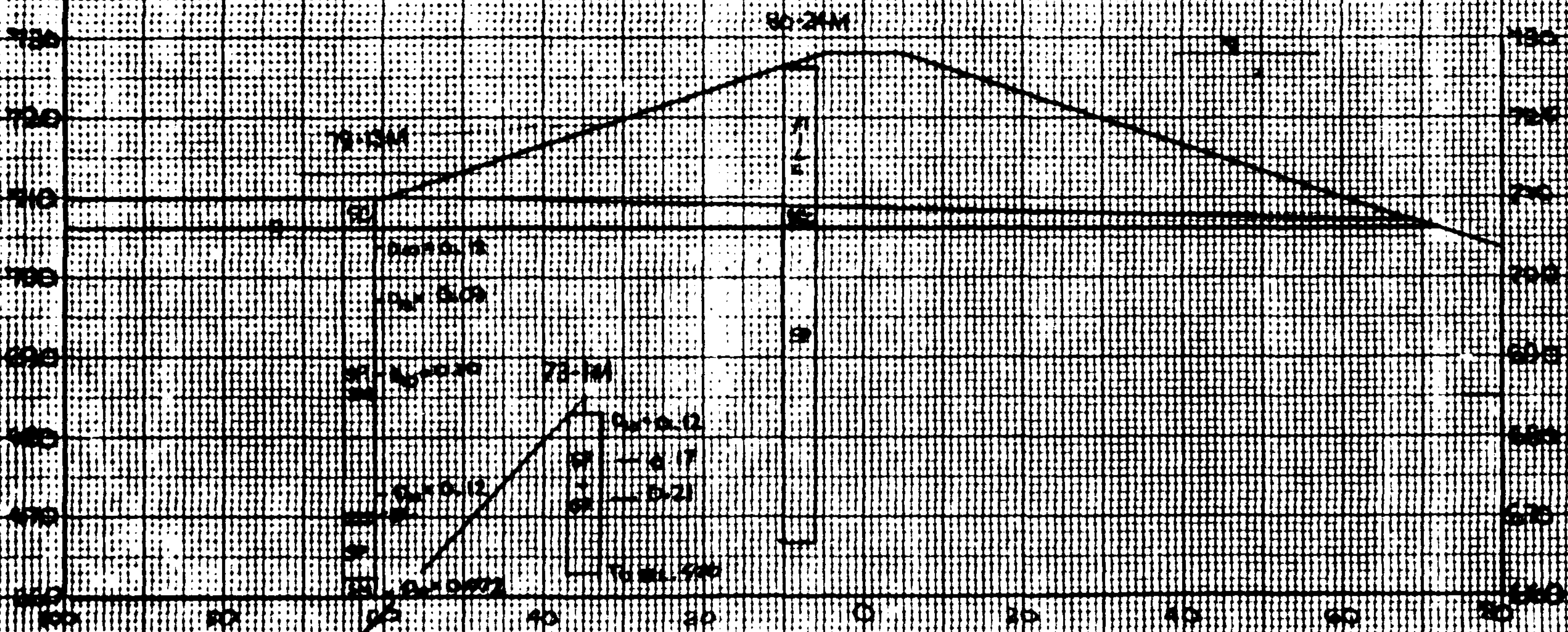


Figure 27

Name of Office: ED-GH	Project: CHASKA		
SECTION 4- BERM DESIGN			
Computed by: LHB	Checked by	Approved by	Price Level

Z_T TOP ELEVATION = 710.2 $\quad I_o = 0.3 \quad I_1 = 0.8$

$R = 0.3/0.8 = 0.375$

$A = 6 + 3(183.4)(0.0037)(1.375) = 8.8 \quad S = 183.4' \quad x_3 = 267.1'$

$h = 17.8 \quad H_o = 10.55'$

$h_A = 0.8(4.1) = 3.28'$

$$X_{SP} = \frac{-8.8 + \sqrt{(8.8)^2 - 24(2.375)(1 + 0.0037(183.4) - (17.8/3.28))}}{2(2.375)(0.0037)}$$

$X_{SP} = 470'$

$H_o' = 3.28\left(1 + 0.0037(470) + \frac{2.375}{6}(0.0037(470))^2\right] = 12.91$

$X_P = 267.1 \ \ln\left(12.91/3.28\right) = 366.0'$

$X_S = 1/3(366 + 2(470)) = 435.3' \quad$ (USE 440')

REQUIRED LENGTH IS TOO LONG TO BE PRACTICAL -

Z_T TOP ELEVATION = 713.0 $\quad S = 183.4' \quad x_3 = 301.4'$

$h = 15.0 \quad h_A = .8(6.9) = 5.52$

$R = 0.375$

$A = 6 + 3(183.4)(0.0033)(1.375) = 8.5'$

$$X_{SP} = \frac{-8.5 + \sqrt{(8.5)^2 - 24(2.375)(1 + (0.0033(183.4)) - 15/5.52)}}{2(2.375)(0.0033)}$$

$X_{SP} = 200.7'$

$H_o' = 5.52\left(1 + 0.0033(200.7) + \frac{2.375}{6}(0.0033(200.7))^2\right] = 10.13$

$X_P = 301.4 \ \ln\left(10.13/5.52\right) = 183'$

$X_S = 1/3(183 + 2(200.7)) = 194.8' \quad$ USE 195'

$H_o' = 5.52\left(1 + .0033(195) + \frac{2.375}{6}(0.0033(195))^2\right] = 9.98'$

$$t = \frac{9.98 - 6.9\left(\frac{60}{1.6(62.4)}\right)}{1 + \left(\frac{57.5}{1.6(62.4)}\right)} = \frac{5.83}{1.58} = 3.7'$$

RECOMMEND FILL TO ELEVATION 713.0 AND CONSTRUCT BERM 4.5' THICK AT LEVEE TOE, 195 WIDE, 1V ON 60H.

SECTION IS NOT AFFECTED BY INCREASED G.S. ELEVATION

NCS FORM 34
1 NOV 1976

Figure 28

EOT..
E)

PAGE 1

CHASKA MINNESOTA - MN RIVER LEVEE
SECTION B RELIEF WELL DESIGN
LHB 8 INCH DIA. FEB 1984

INPUT DATA

D	FK	X3	S	H	WHT	RL
128.900	0.108	267.100	183.400	17.800	-3.000	3.000

DIA	RV	FREE	WD1	SAFE	F	U
8.000	0.900	3.000	0.000	1.000	1.700	0.000

LAYER	ZT(I)	GAM(I)
1	4 2	125.00

PROGRAM COMMENTS:
SCREEN LENGTH= 128.900

OUTPUT DATA

WD	SP	QW	V	HW	HAV	HAV1	TAU	TAU1
0.40	57.934	448.	2.861	-2.577	2.479	5.055	1.175	1.175
0.50	69.409	542.	3.463	-2.446	2.387	4.842	0.930	0.930
0.60	75.154	605.	3.865	-2.331	2.144	4.475	0.770	0.770
0.70	80.167	659.	4.212	-2.206	1.963	4.170	0.658	0.658
0.80	84.538	706.	4.510	-2.075	1.830	3.905	0.576	0.576
0.90	88.280	746.	4.763	-1.940	1.731	3.671	0.512	0.512
1.00	91.522	780.	4.981	-1.803	1.655	3.458	0.462	0.462

WD	TR1	QVEW	QSW	QS	R	HAV B	HR1	TR
0.40	1.083	6.733	0.680	7.413	138.	1.744	0.000	0.000
0.50	0.946	6.808	0.649	7.458	136.	1.665	4.924	0.946
0.60	0.827	7.027	0.560	7.587	131.	1.437	4.810	0.827
0.70	0.740	7.186	0.495	7.682	128.	1.271	4.685	0.740
0.80	0.672	7.305	0.447	7.752	125.	1.147	4.553	0.671
0.90	0.617	7.396	0.410	7.806	122.	1.051	4.419	0.617
1.00	0.572	7.467	0.381	7.848	120.	0.978	4.282	0.572

RUN COMPLETE

Figure 29

PAGE 1

[illegible] MINNESOTA   MN RIVER LEVEE
RELIEF WELL DESIGN FOR SECTION B
MB   12 INCH DIA   FEB 1984

INPUT DATA

D	KF	H3	S	H	WHT	EL
128.900	0.108	267.100	183.400	17.500	3.000	7.000

DIA	RW	FREE	VD1	SAFE	F	U
12.000	0.500	3.000	0.000	1.000	1.700	0.000

LAYER	ZT(I)	GAM I
1	4.2	125.00

PROGRAM COMMENTS:
SCREEN LENGTH= 129.900

OUTPUT DATA

WD	SP	QW	V	HW	HAV	HAV1	TAV	TAV1
0.40	60.791	469.	1.332	2.825	2.479	5.304	1.177	1.177
0.50	72.770	572.	1.625	-2.802	2.340	5.143	0.936	0.936
0.60	79.946	649.	1.843	-2.783	2.073	4.856	0.779	0.779
0.70	86.676	720.	2.044	-2.760	1.877	4.637	0.670	0.670
0.80	92.999	786.	2.231	-2.733	1.728	4.461	0.591	0.591
0.90	98.946	847.	2.404	-2.703	1.614	4.317	0.531	0.531
1.00	104.542	904.	2.566	-2.669	1.524	4.193	0.483	0.483

WD	TM1	QUEW	QSU	QS	R	HAV B	HM1	TM
0.40	1.101	6.721	0.685	7.406	140.	1.757	0.000	0.000
0.50	0.961	6.838	0.637	7.475	138.	1.635	5.281	0.961
0.60	0.844	7.062	0.546	7.608	133.	1.400	5.262	0.844
0.70	0.757	7.227	0.479	7.706	130.	1.288	5.239	0.757
0.80	0.690	7.352	0.428	7.780	128.	1.097	5.212	0.690
0.90	0.637	7.450	0.388	7.838	126.	0.995	5.181	0.637
1.00	0.593	7.588	0.356	7.884	124.	0.914	5.148	0.593

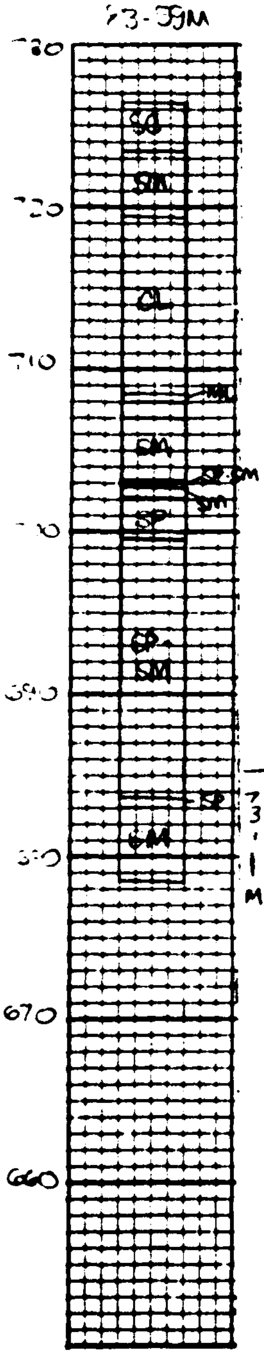
RUN COMPLETE

Figure 30

BORING EVALUATION SHEET PROJECT: CHASKA - MN RIVER LEVEE

BORING NO. : 73-59M, 73-6M DATE: JAN 84

BLANKET SECTION 4A ELEV. TOP OF FLOOD BARRIER: 728.0



SOIL UNIT	TOP ELEV.	$K_v \times 10^4$ (1)	γ_m	Z_i	F_t (6)	Z_b	Z_t	ΣZ_b	ΣZ_t	Σ WT. (5)	$\Sigma WT./\gamma_w$
ML	710.0	10	53.5	2.0	1	2.0	2.0	5.6	5.6	314.7	5.04
SM	708.0	16	57.5	4.5	.63	2.84	2.84	3.6	3.6	207.7	
SP-SM	703.5	40	62.5	0.5	.25	.13	.13	.76	.76	44.4	
SM	703.0	16	57.5	1.0	.63	.63	.63	.63	.63	36.2	

MINIMUM $K_v \times 10^4$ = 10 FPM

(1) SEE PAGE 265 T.M. 3-424 (2) SEE PAGE 44 T.M. 3-424
(3) G= GRADATION, P=PERMEABILITY TEST, A=ASSUMED VALUES
(4) SEE PAGE 51 T.M. 3-424 (5) WT.= $Z_t * \gamma'_m$ (6) F_t=TRANS.FACTOR

PERVIOUS ZONE

SOIL UNIT	TOP ELEV.	d	D_{10}	SOURCE (4)	K_h (3)	$\Sigma K_h * d$	D=Σd
SP	702	8.6	0.20	G	.20	1.720	8.6
SP-SM	693.4	6.0	0.08	G	.02	0.120	14.6
SP	687.4	4.0	0.13	G	.079	0.316	18.6
SM	683.4	—	—	–	—	—	18.6
SP	678.5	1.5	0.11	G	.052	0.078	20.1
SP	677	4.5	0.16	G	.12	0.540	24.6
SW-SM	672.5	7.3	0.095	A	0.033	0.241	31.9
CL	665.2	—	—	A	—	—	31.9
SW-SM	664	19.5	0.12	A	0.066	1.287	51.4
SP-SM	644.5	18.5	0.17	A	0.14	2.590	69.9
GP	626	19.0	0.21	A	0.22	4.180	88.9
SP	607	9.0	0.19	A	0.18	1.620	97.9
SP	597	22.0	0.12	A	0.066	1.452	119.9
CL-CH	576					14.144	

K_f= 0.118 FPM, c= 0.0036, X_3= 281.5 FT

SUMMARY COMPUTATIONS

Z_t-TOP ELEV	H	S	X_3	H_0	X	H_x	$\Sigma WT./\gamma_w$	F.S.
710	18	214.9'	281.5	10.2	0	10.2	5.04	0.49

v. scale
1" = 10'

Figure 31

$L_1 = 100'$ $\qquad X_1 = \dfrac{\tanh(0.0036 \times (100))}{0.0036} = 95.9'$ $\qquad S = 119 + 95.9 = 214.9'$

$h_0 = 18\left[\dfrac{281.5}{281.5 + 214.9}\right] = 10.2'$

$i = \dfrac{10.2}{[illegible] + 281.5} = 0.242$ $\qquad Q_s = 0.242(0.118)(15)(7.48)\frac{gal}{ft^3} = 3.20$ GPM/FT OF LEVEE

SEEPAGE CASE 7 - SEMI-PERVIOUS BLANKET (BOTH SIDES)

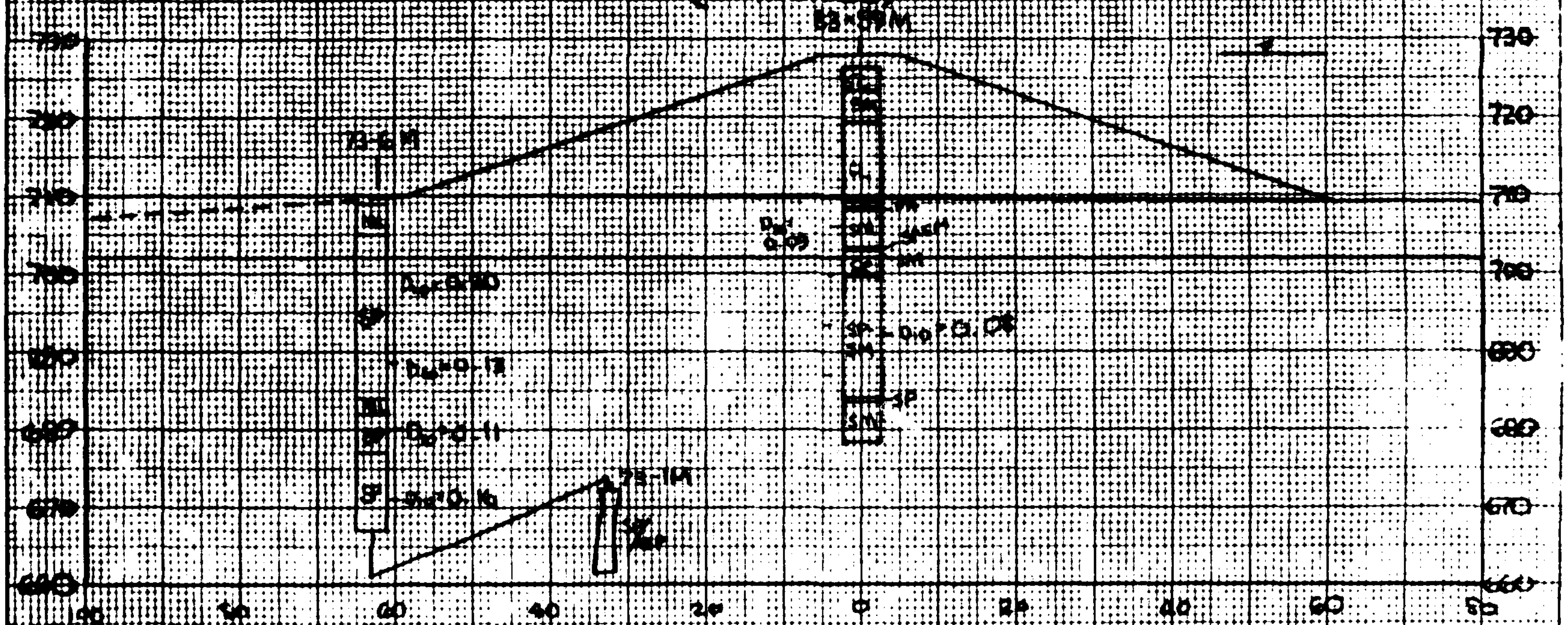


Figure 32

COMPUTATION SHEET

Date JAN 84	Page 3 of 3		
Name of Office ED-GH	Project CHASKA BERM DESIGN		
SECTION 4A			
Computed by LHB	Checked by	Approved by	Price Level

Z_T TOP ELEVATION = 710.0 $\quad H_A = 0.8(5.6) = 4.48'$

$I_0 = 0.3 \quad I_1 = 0.8 \quad R = 0.3/.08 = 0.375$

$S = 214.9' \quad X_3 = 281.5' \quad C = 0.0036$

$$A = 6 + 3(214.9)(0.0036)(1.375) = 9.19$$

$$X_{SP} = \frac{-9.19 + \sqrt{(9.19)^2 - 24(2.375)\left(1 + (0.0036(214.9) - 18/4.48)\right)}}{2(2.375)(0.0036)}$$

$$X_{SP} = 314.8 \text{ FT}$$

$$H_0' = 4.48\left[1 + 0.0036(314.8) + 2.375/6\,(0.0036(314.8))^2\right] = 11.83'$$

$$X_P = 281.5' \ \mathrm{Ln}\left(11.83/4.48\right) = 273.3'$$

$$X_S = 1/3\left(273.3 + 2(314.8)\right) = 301.0'$$

$$H_0' = 4.48\left[1 + (0.0036(301)) + 2.375/6\,(0.0036(301))^2\right] = 11.42'$$

$$t = \frac{11.42 - 5.6\left(\frac{60}{1.6(62.4)}\right)}{1 + \left(57.5/1.6(62.4)\right)} = \frac{8.05}{1.58} = 5.1 \text{ FT}$$

THICKNESS = 6.5'

WIDTH = 301'

1 V ON 50 H.

NCS FORM 34
1 NOV 1976

Figure 13

PAGE 1

CHASKA MINNESOTA - MN RIVER LEVEE
RELIEF WELL DESIGN FOR SECTION 9
LHB FEB 1984

INPUT DATA
****

D	FX	X3	S	H	WHT	RL
119 900	0 118	281 500	214 900	18 000	-3 000	7 000

DIA	RW	FREE	WD1	SAFE	F	U
12 000	0 800	3 000	0.000	1 000	1 700	0 000

LAYER	ZT(I)	GAM(I)
1	2 0	116 00
2	2 8	120 00
3	0 1	125 00
4	0 6	120 00

PROGRAM COMMENTS
****
SCREEN LENGTH 119 900

OUTPUT DATA
****

WD	SP	QW	V	HW	HAV	HAV1	TAV	TAV1
0 40	79 156	506	1 435	-2 795	2 852	5 647	1 182	1 182
0 50	89 376	593	1 684	-2 780	2 565	5 346	0 954	0 954
0 60	98 966	674	1 912	-2 760	2 370	5 130	0 806	0 806
0 70	107 980	748	2 123	-2 735	2 231	4 966	0 703	0 703
0 80	116 473	817	2 319	-2 706	2 128	4 834	0 626	0 626
0 90	124 485	882	2 503	-2 673	2 051	4 725	0 567	0 567
1 00	132 039	942	2 674	-2 638	1 992	4 630	0 520	0 520

WD	HM1	QUEW	QSW	QS	R	HAV D	HM1	TM
0 40	1 207	5 558	0 787	6 355	169	2 094	5 767	1 207
0 50	1 026	5 786	0 693	6 479	163	1 843	5 752	1 026
0 60	0 900	5 935	0 628	6 564	159	1 672	5 731	0 900
0 70	0 807	6 042	0 582	6 624	156	1 548	5 706	0 807
0 80	0 735	6 122	0 548	6 669	153	1 457	5 677	0 735
0 90	0 678	6 182	0 522	6 704	152	1 388	5 645	0 678
1 00	0 630	6 229	0 501	6 730	150	1 334	5 609	0 630

RUN COMPLETE
EOI

Figure 34 3

PAGE 1

8 - INCH WELL

INPUT DATA

D	FK	X3	S	H	WHT	RL
117 900	0 118	281 500	214 900	18 000	-3 000	7 000

DIA	RW	FREE	WD1	SAFE	F	U
8 000	0 800	3 000	0 000	1 000	1 700	0 000

LAYER	ZT(I)	GAM(I)
1	2 0	116 00
2	2 8	120 00
3	0 1	125 00
4	0 6	120 00

PROGRAM COMMENTS
****
SCREEN LENGTH= 119 900

OUTPUT DATA

WD	SP	QW	V	HW	HAV	HAV1	TAV	TAV1
0 40	73 389	485	3 097	-2 494	2 898	5 392	1 177	1 177
0 50	85 187	561	3 582	-2 385	2 626	5 012	0 946	0 946
0 60	92 972	627	4 002	-2 263	2 446	4 709	0 795	0 795
0 70	99 831	684	4 366	-2 130	2 322	4 452	0 689	0 689
0 80	105 882	733	4 682	-1 989	2 235	4 224	0 610	0 610
0 90	111 115	775	4 951	-1 846	2 172	4 019	0 549	0 548
1 00	115 707	812	5 185	-1 700	2 128	3 828	0 499	0 499

WD	TM1	QUEW	QSW	QS	R	HAV B	HM1	TM
0 40	1 193	5 544	0 798	6 342	168	2 122	5 465	1 193
0 50	1 011	5 757	0 706	6 462	161	1 877	5 357	1 011
0 60	0 884	5 900	0 644	6 544	155	1 712	5 234	0 884
0 70	0 790	6 002	0 599	6 602	152	1 595	5 101	0 790
0 80	0 716	6 074	0 568	6 642	150	1 512	4 961	0 716
0 90	0 657	6 129	0 545	6 674	147	1 448	4 818	0 658
1 00	0 609	6 169	0 527	6 696	145	1 402	4 672	0 609

RUN COMPLETE
EOT
L>

Figure 35

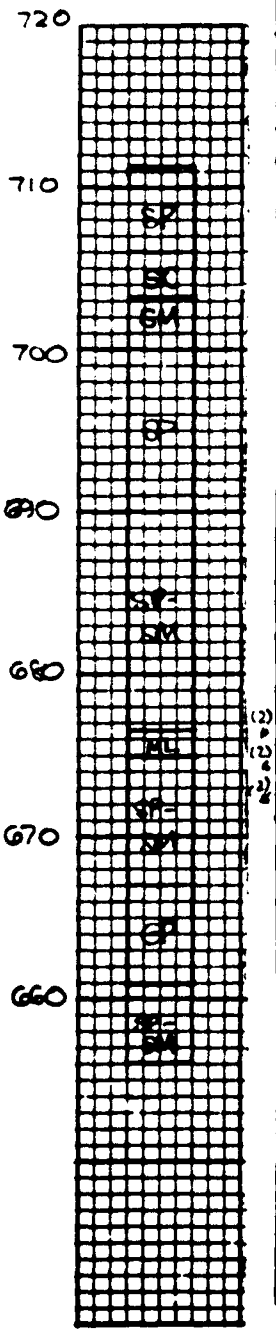
BORING EVALUATION SHEET

PROJECT: CHASKA - MN RIVER LEVE

BORING NO. : 79-12M

DATE: FEB. 84

ELEV. TOP OF FLOOD BARRIER: 728.C



BLANKET

SOIL UNIT	TOP ELEV.	$K_v \times 10^4$ (1)	γ_m	Z_i	F_t (6)	Z_b	Z_t	ΣZ_b	ΣZ_t	ΣWT. (5)	ΣWT./γ_w
SP	711.2	20	62.5	5.2	.4	2.08	5.2	5.82	8.94	554.6	8.89
SC	706	8	62.5	2.9	1.0	2.9	2.9	3.74	3.74	229.6	
SM	703.1	20	57.5	2.1	.4	.84	.84	.84	.84	48.3	

MINIMUM $K_v \times 10^4$ = 8 FPM

(1) SEE PAGE 265 T.M. 3-424 (2) SEE PAGE 44 T.M. 3-424
(3) G= GRADATION, P=PERMEABILITY TEST, A=ASSUMED VALUES
(4) SEE PAGE 51 T.M. 3-424 (5) WT.= $Z_t \cdot \gamma_m'$ (6) F_t=TRANS.FACTOR

PERVIOUS ZONE

SOIL UNIT	TOP ELEV.	d	D_{10}	SOURCE (4)	K_h (3)	$\Sigma K_h \cdot d$	D= Σd
SP	701	10	.18	G	.16	1.600	10
SP-SM	691	14.5	.17	G	.14	2.030	24.5
ML	676.5	—	—	—	—	—	24.5
SP-SM	675.0	8.0	.16	G	.12	0.960	32.5
GP	667.0	6.0	.20	A	.20	1.200	38.5
SP-SM	661.0	7.0	.18	G	.16	1.120	45.5
SP	654.0	22.0	.12	A	.066	1.452	67.5
CL-CH	632.0						
						8.362	

K_f= 0.124 FPM, c= 0.0041, X_3= 246.8' FT

SUMMARY COMPUTATIONS

Z_t-TOP ELEV	H	S	X_3	H_0	X	H_x	ΣWT./γ_w	F.S.
711.2	17	491.3	246.8	5.68	0	5.68	8.89	1.58

* SEE Pg 2.

v. scale
1" = 10'

Figure 36

1) ASSUME THAT INSPECTION TRENCH CUTS OFF SP LAYER IN BLANKET.

2) THE BASE OF AQUIFER IS ASSUMED BASED UPON RELATIVE DISTANCES BETWEEN THE SP LAYER OF 73-11M AND 73-12M. THIS ASSUMES THAT THE SILT/CLAY LAYER THAT DROPPED OFF SO DRAMATICALLY @ 73-1M IS THE SAME LAYER/S SURFACING ON THE EAST CREEK SIDE OF CHASKA.

$h_o = 14\left[\frac{246.8'}{246.8+361.3}\right] = 5.68'$ $\quad s = 130 + 361.3 = 491.3'$ $\quad L_1 = 200'$ TO SEEPAGE BLOCK

$x_1 = 1/0.0041(\tanh(0.0041(200))) = 361.3'$ $\quad i = \frac{67.5}{491.3 + 246.8} = 0.092$

$Q_s = 0.092(0.124)(14)(7.48 \frac{GPM}{FT^3/M}) = 1.19$ GPM/FT. OF LEVEE

SEEPAGE CASE 7 - SEMI PERVIOUS BLANKET (BOTH SIDES)

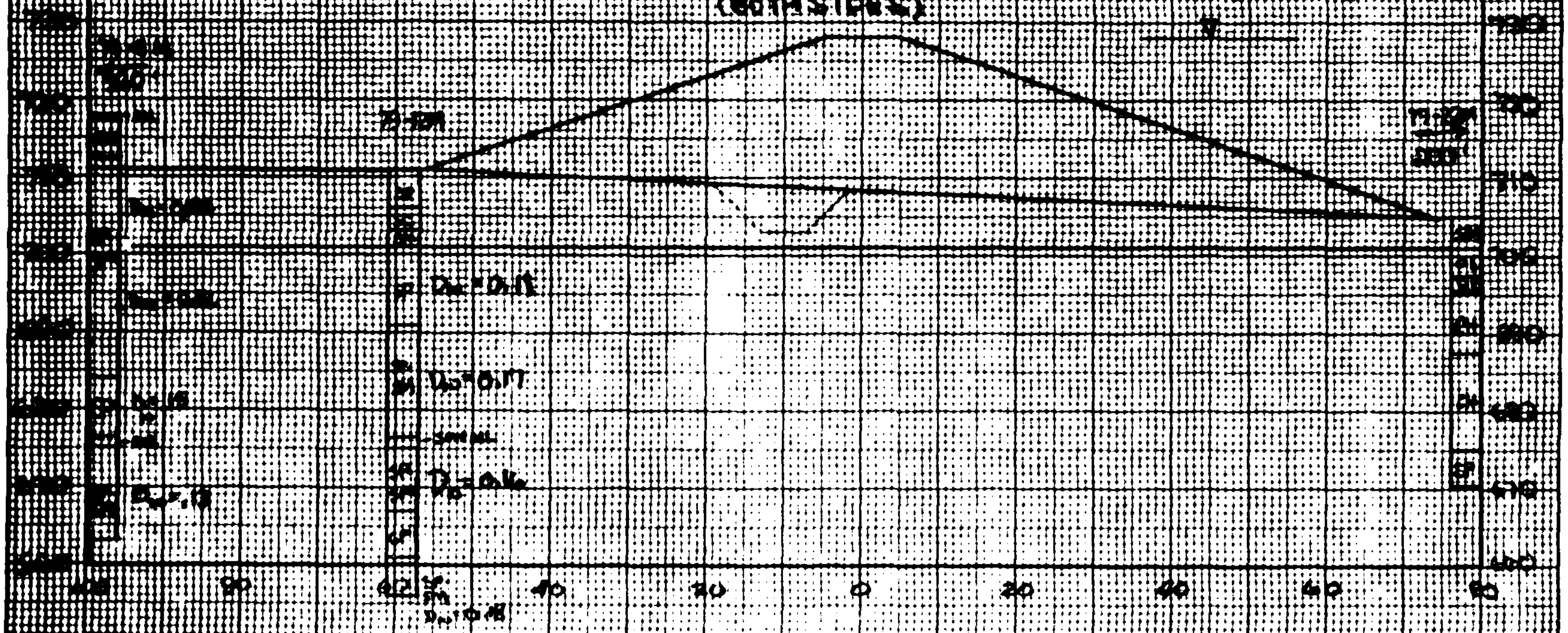
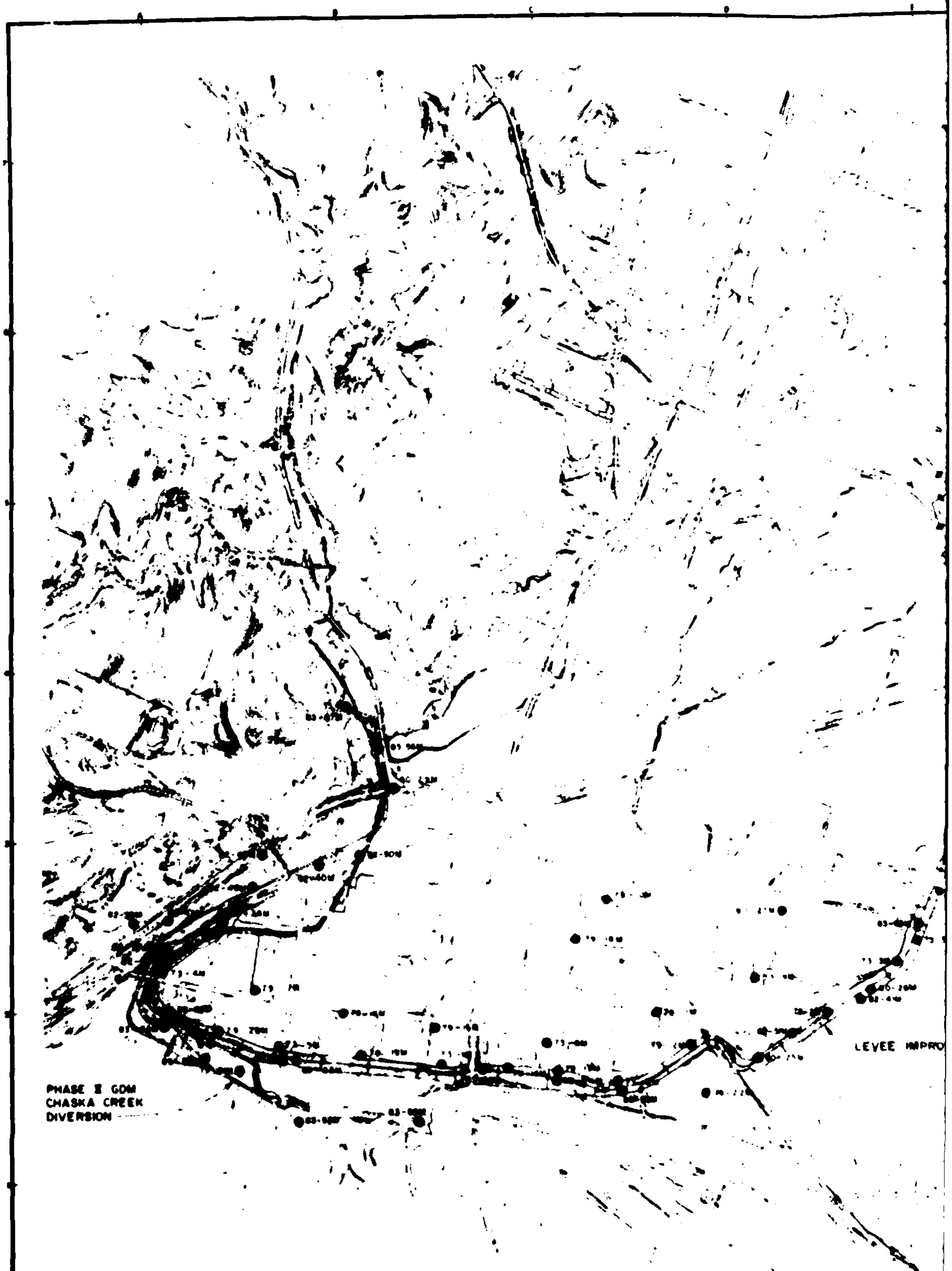


Figure 37


PHASE II GDM
CHASKA CREEK
DIVERSION
LEVEE IMPRO

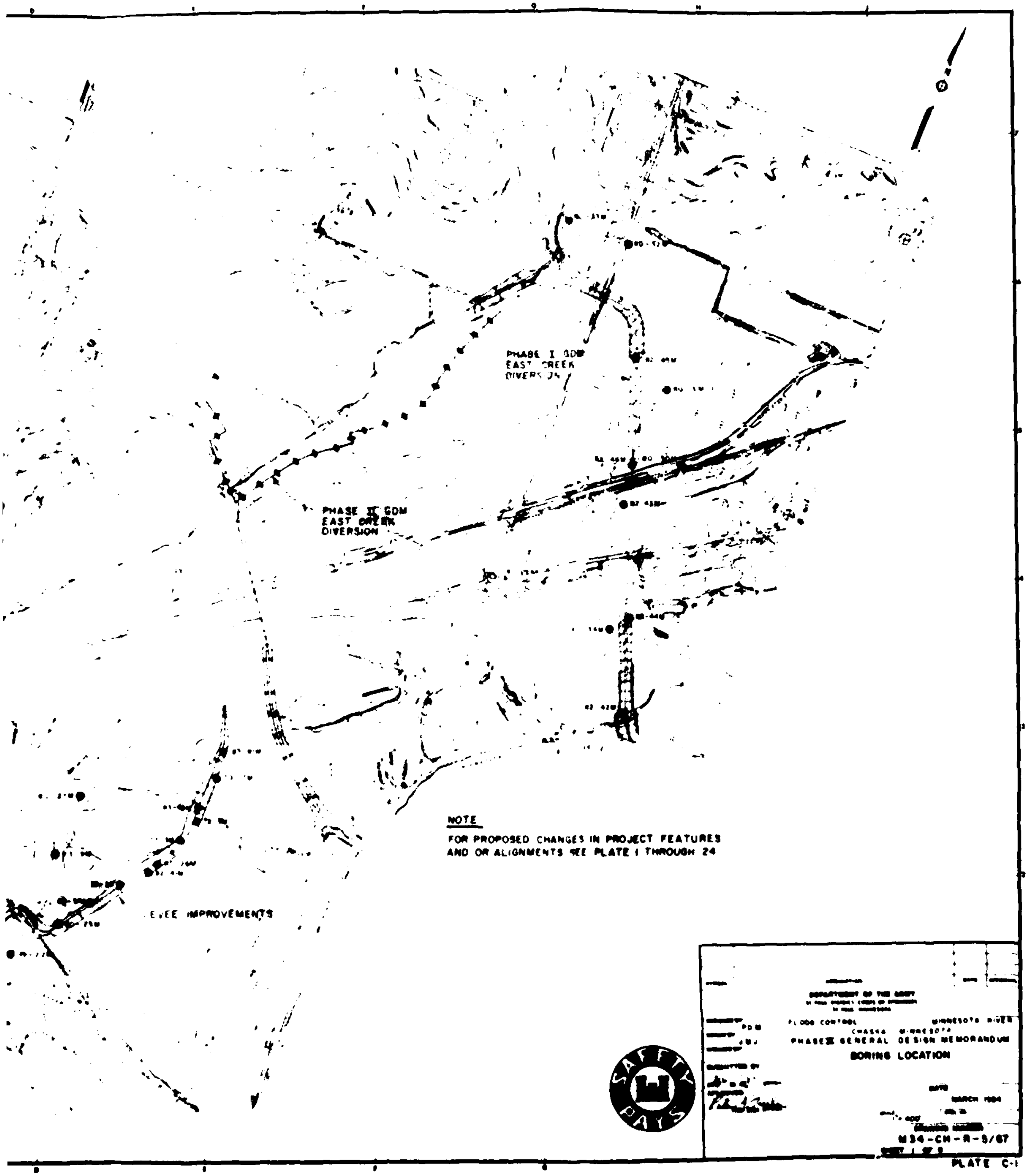
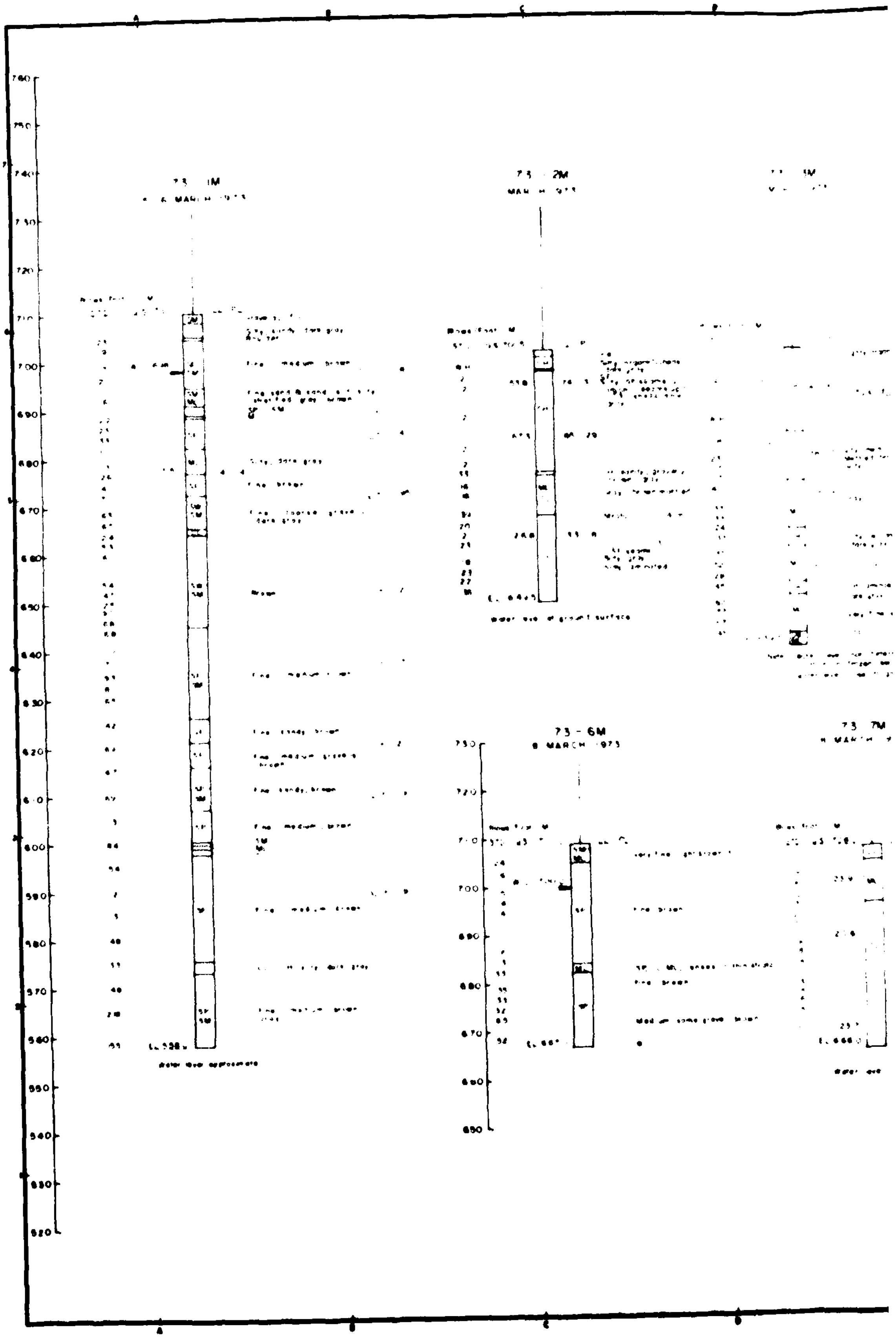
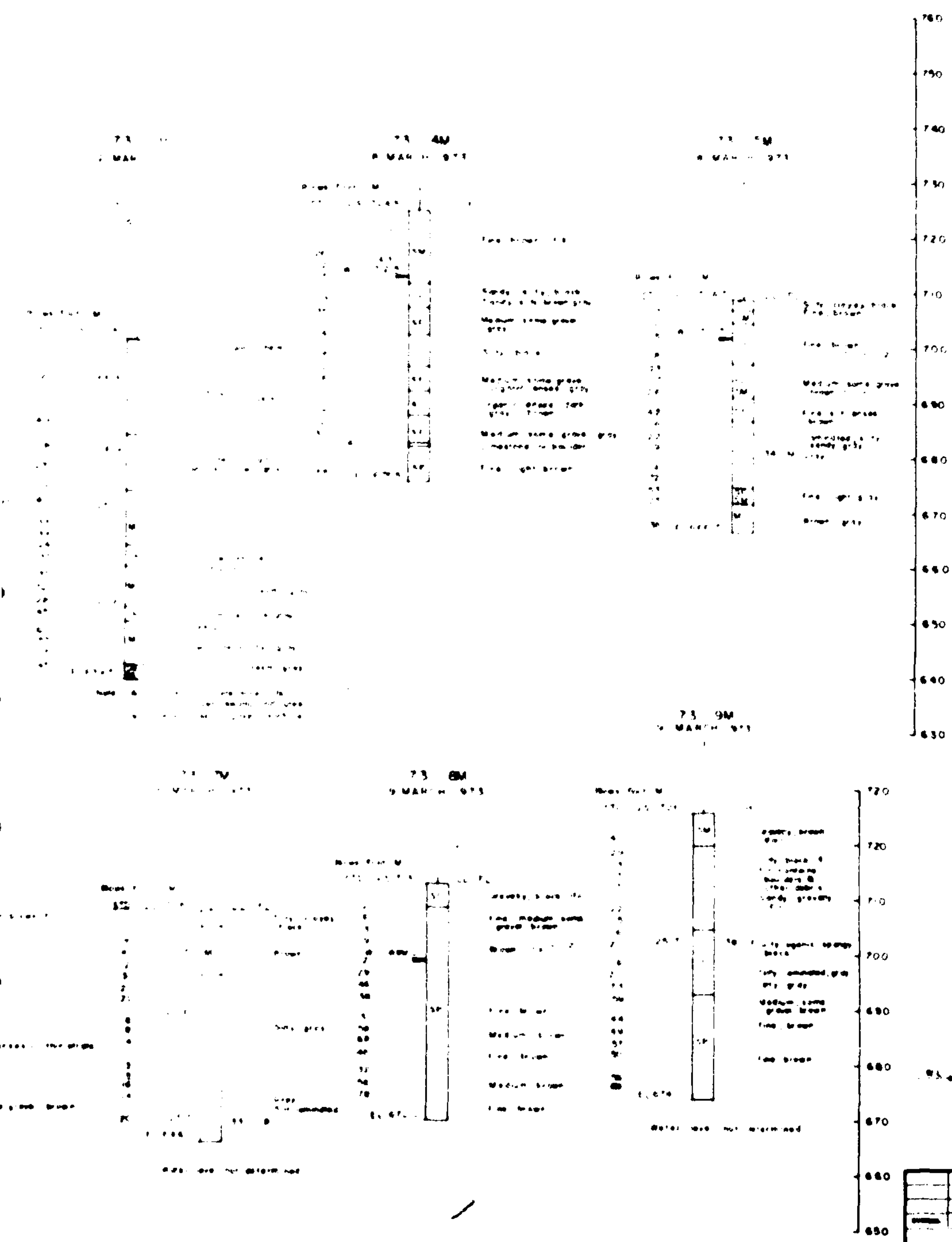

PHASE I GDM
EAST CREEK
DIVERSION
PHASE II GDM
EAST CREEK
DIVERSION
LEVEE IMPROVEMENTS
NOTE
FOR PROPOSED CHANGES IN PROJECT FEATURES
AND OR ALIGNMENTS SEE PLATE 1 THROUGH 24
SAFETY PAYS
DEPARTMENT OF THE ARMY
FLOOD CONTROL
MINNESOTA RIVER
CHASKA MINNESOTA
PHASE II GENERAL DESIGN MEMORANDUM
BORING LOCATION
MARCH 1984
M34-CH-R-5/67

PLATE C-1



73 - 1M
73 - 2M
73 - 6M
6 MARCH 1973
73 - 7M
760
750
740
730
720
710
700
690
680
670
660
650
640
630
620
610
600
590
580
570
560
550
540
530
520



BORING NOTES

1. General: the legend presents only the basic soils. To complete the classification, pertinent information is added to the right of the boring log.
2. Dual classification: where soil is considered to be on the border line of two or more groups a double symbol is used. I.E. (GP GM) or (CL CM)
3. Blow count: blow counts are shown to the left of the boring logs and are the number of blows necessary to drive the sampler used a distance of 12 inches. Sampler size and penetration effort are noted on the logs. All unmarked blow counts are for a standard penetration test, using a 1 3/8" x 2" sampler, 140 lb hammer and 30" drop.
4. Soil color is shown as lt (light), dk (dark), br (brown), gr (gray) and bl (black) to the right of the boring log.
5. For boring locations, see plate 5.
6. Elevation: all elevations shown are in feet (M.S.L. - U.S.G.S. 1912 tp).
7. Moisture content: the natural moisture content in percent of dry weight is shown to the left of the boring log.
8. Atterberg limits: liquid limit (LL) and plastic limit (PL) are shown to the right of the boring log.

GW	
GP	POORLY GRADED GRAVELS LITTLE OR NO FINES
GM	
GC	CLAYEY GRAVELS, GRAVEL SAND CLAY MIXTURES
SW	WELL GRADED SAND, LITTLE OR NO FINES
SP	POORLY GRADED SANDS, LITTLE OR NO FINES
SM	SILTY SANDS
SC	CLAYEY SANDS
ML	INORGANIC SILTS, LIQUID LIMIT LESS THAN 50
CL	INORGANIC CLAYS, LOW TO MEDIUM PLASTICITY LIQUID LIMIT LESS THAN 50
MH	
CH	INORGANIC CLAYS, HIGH PLASTICITY, LIQUID LIMIT GREATER THAN 50
OL	ORGANIC SILTS OR CLAYS, LOW PLASTICITY
OH	
PT	
	WATER LEVEL AT DATE OF BORING SEE NOTE 7

6B - 6M MACHINE BORING
5 MAY 1970 DATE BORING WAS TAKEN

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

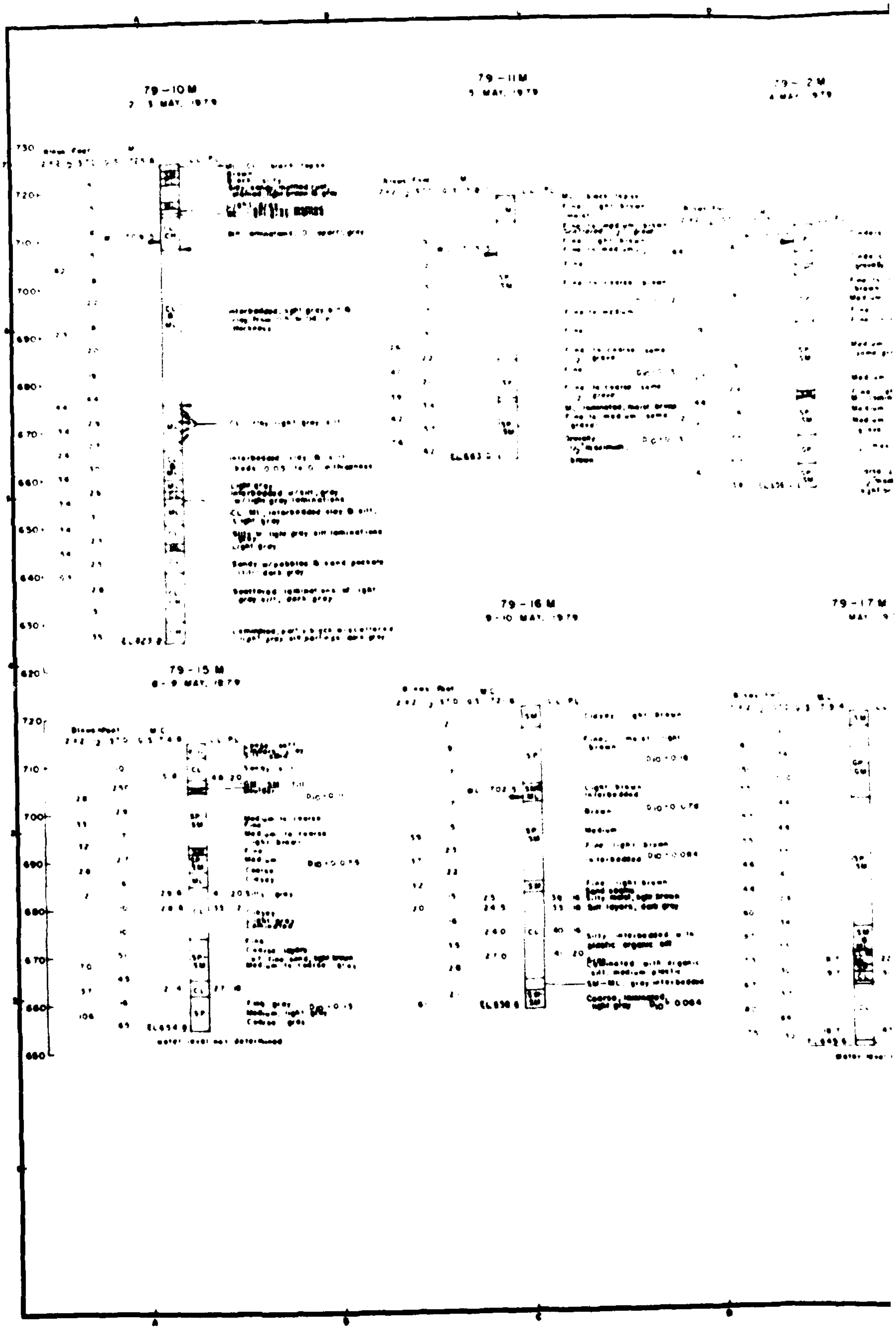
P D M
M T H B S M

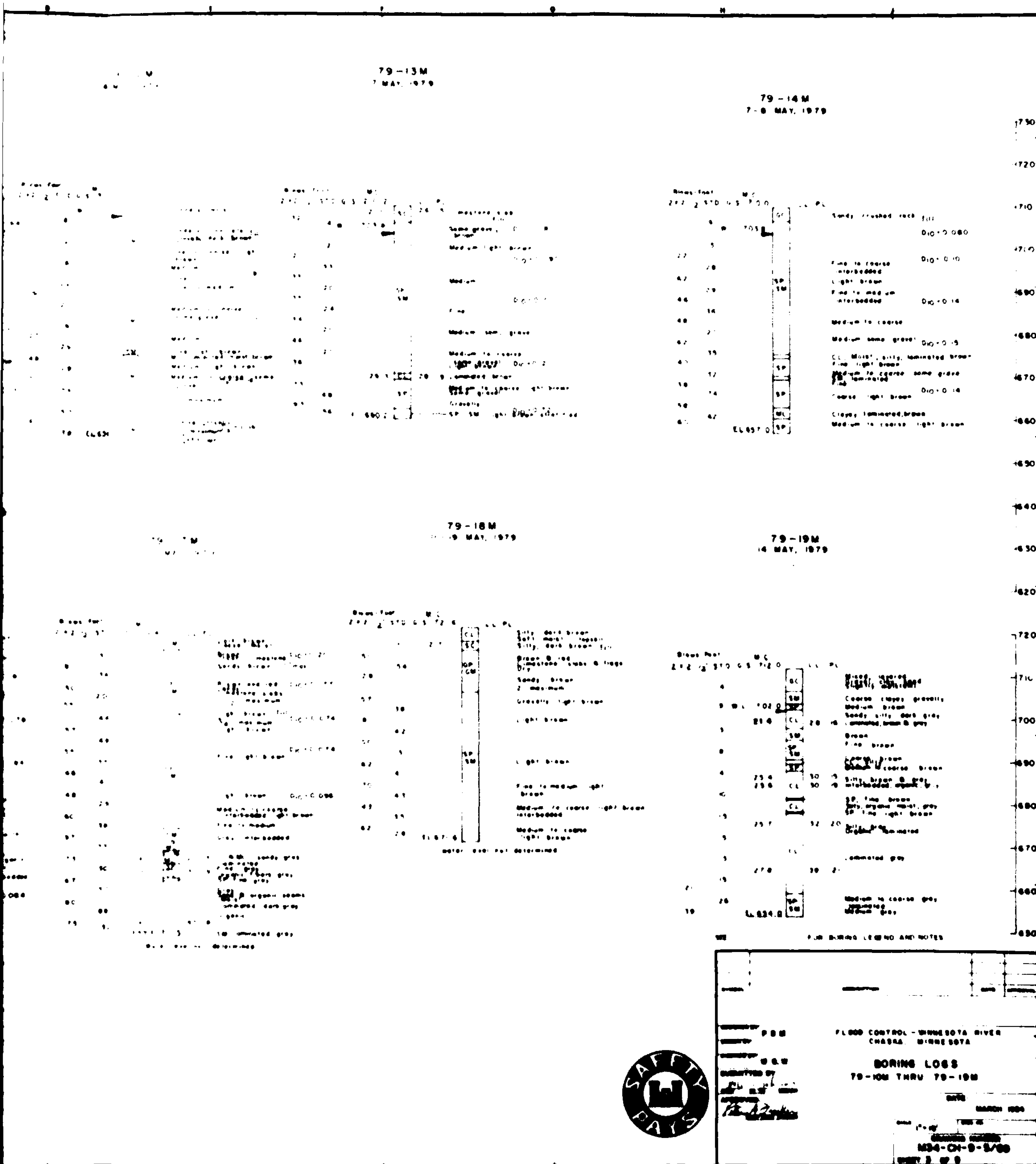
FLOOD CONTROL MINNESOTA RIVER
CHASKA, MINNESOTA

BORING LOGS
73 - 6M THRU 73 - 9M

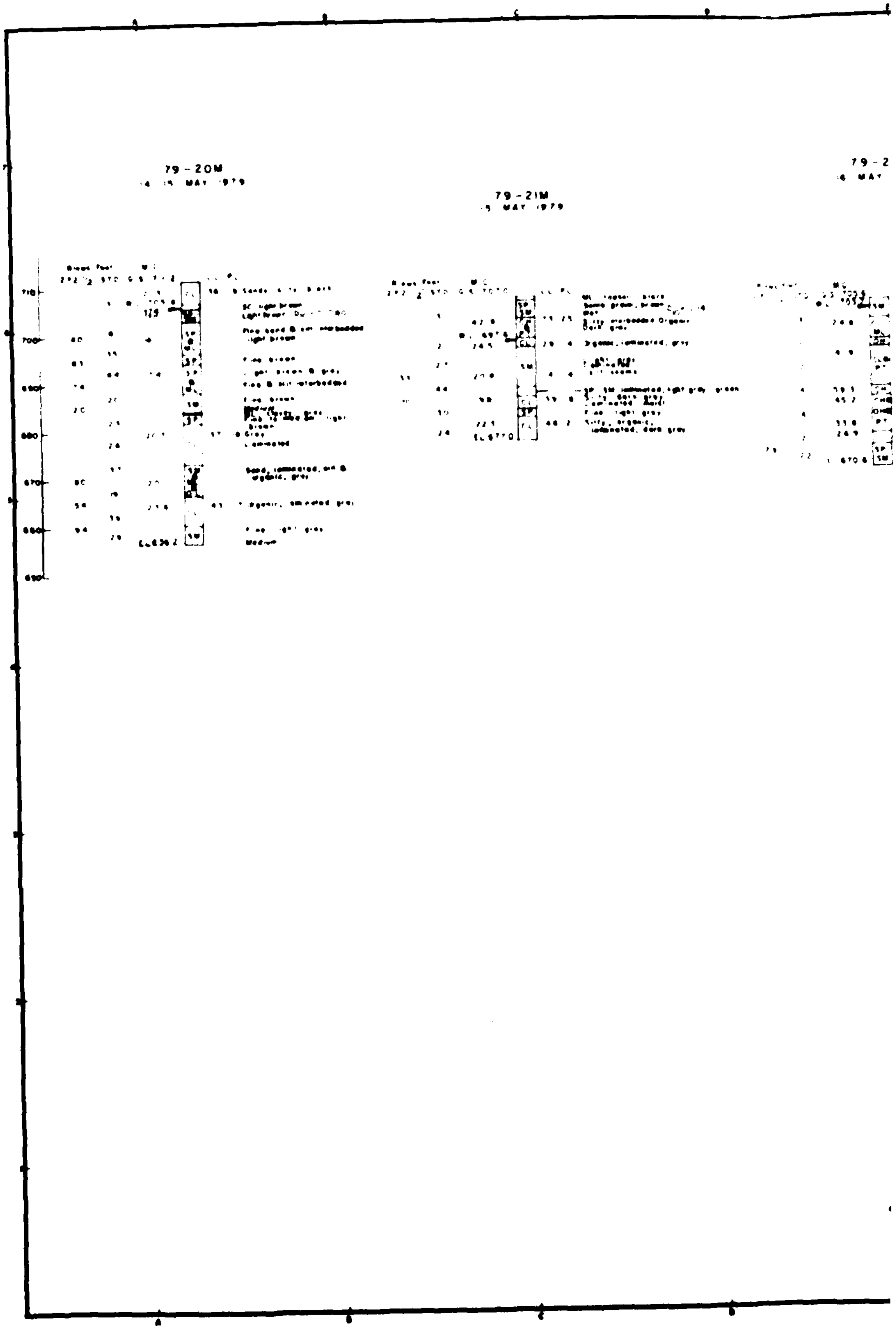
MARCH 1984
1" = 10'
M34-CI-9-5/68
SHEET 2 OF 3

PLATE C-2


79-10 M
2-3 MAY 1979
79-11 M
3 MAY 1979
79-15 M
8-9 MAY 1979
79-16 M
9-10 MAY 1979
79-17 M



79-13M
7 MAY, 1979
79-14M
7-8 MAY, 1979
Sandy, crushed rock
Fill
Fine to coarse interbedded
Light brown
Fine to medium interbedded
Medium to coarse
Medium, some gravel
Coarse, light brown
Clayey, laminated, brown
Medium to coarse, light brown
EL 657.0
79-18M
9 MAY, 1979
79-19M
14 MAY, 1979
Coarse, clayey, gravelly
Laminated, gray
Medium to coarse, gray
EL 634.0
730
720
710
700
690
680
670
660
650
640
630
620
SAFETY PAYS
FLOOD CONTROL - MINNESOTA RIVER
CHASKA, MINNESOTA
BORING LOGS
79-10M THRU 79-19M
MARCH 1980
PLATE C-3


79 - 20M
14 - 15 MAY 1979
79 - 21M
15 MAY 1979
Blows Feet
M.C.
710
700
690
680
670
660
650
Fine, light grey
Medium

FOR BORING LEGEND AND NOTES

FLOOD CONTROL

MINNESOTA RIVER

CHASKA, MINNESOTA

SAFETY PAYS

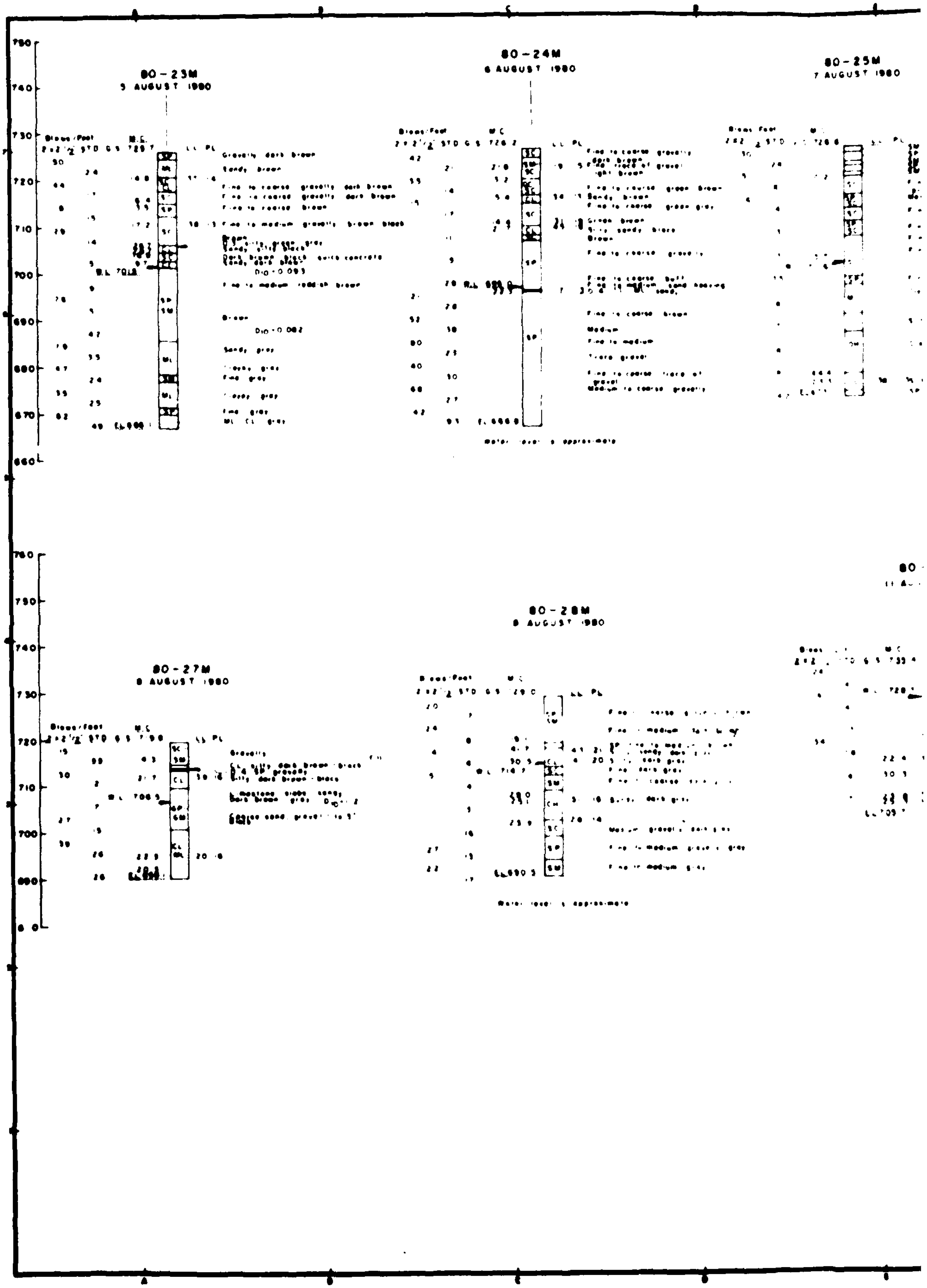
BORING LOGS

79-20M THRU 79-22M

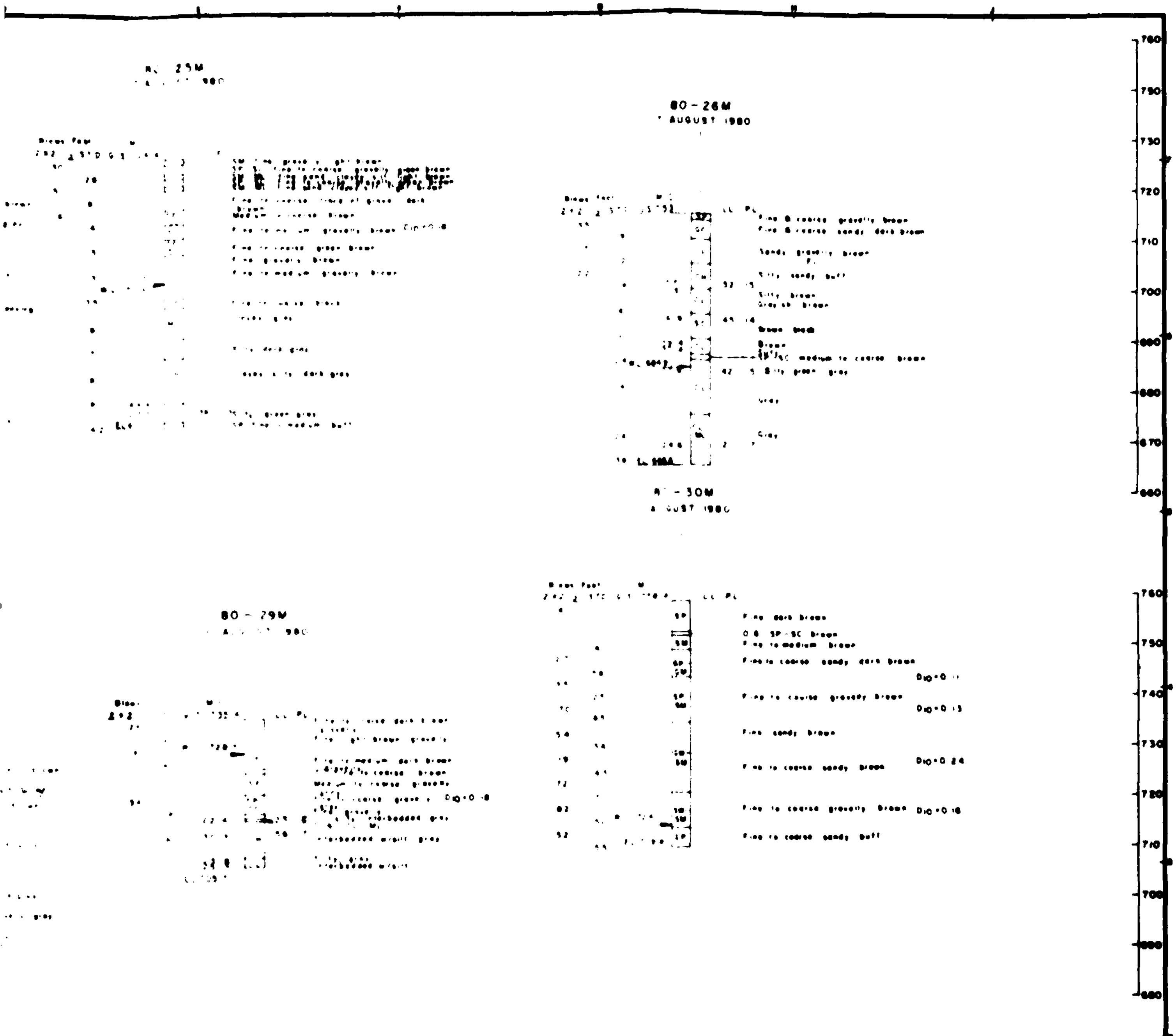
MARCH 1980

M34-CH-9-5/70

PLATE C-4



80-23M
5 AUGUST 1980
80-24M
6 AUGUST 1980
80-25M
7 AUGUST 1980
80-27M
8 AUGUST 1980
80-28M
8 AUGUST 1980
Blows/Foot
Water level is approximate



SEE FOR BORING LEGEND AND NOTES

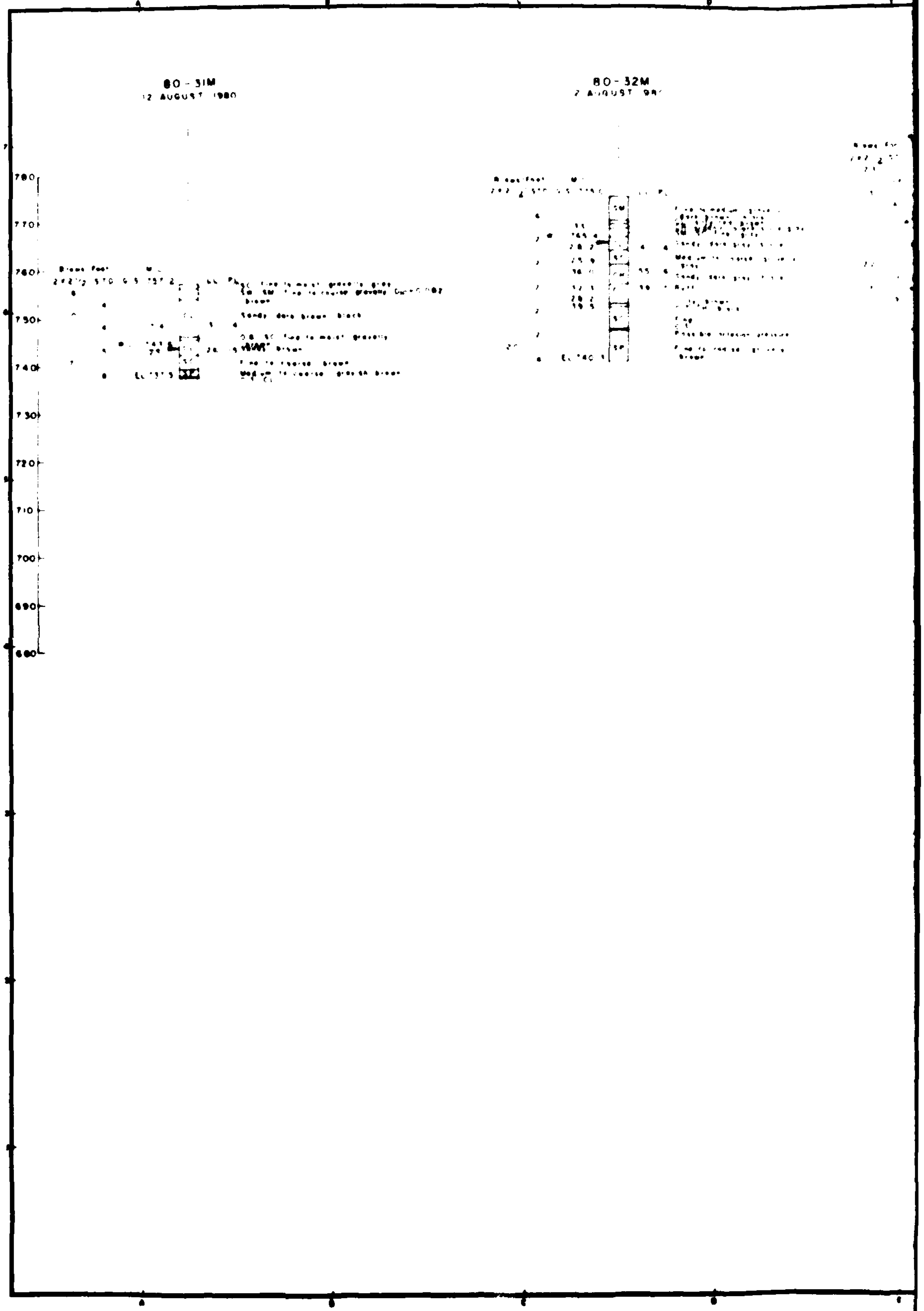
FLOOD CONTROL MINNESOTA RIVER
CHASKA, MINNESOTA

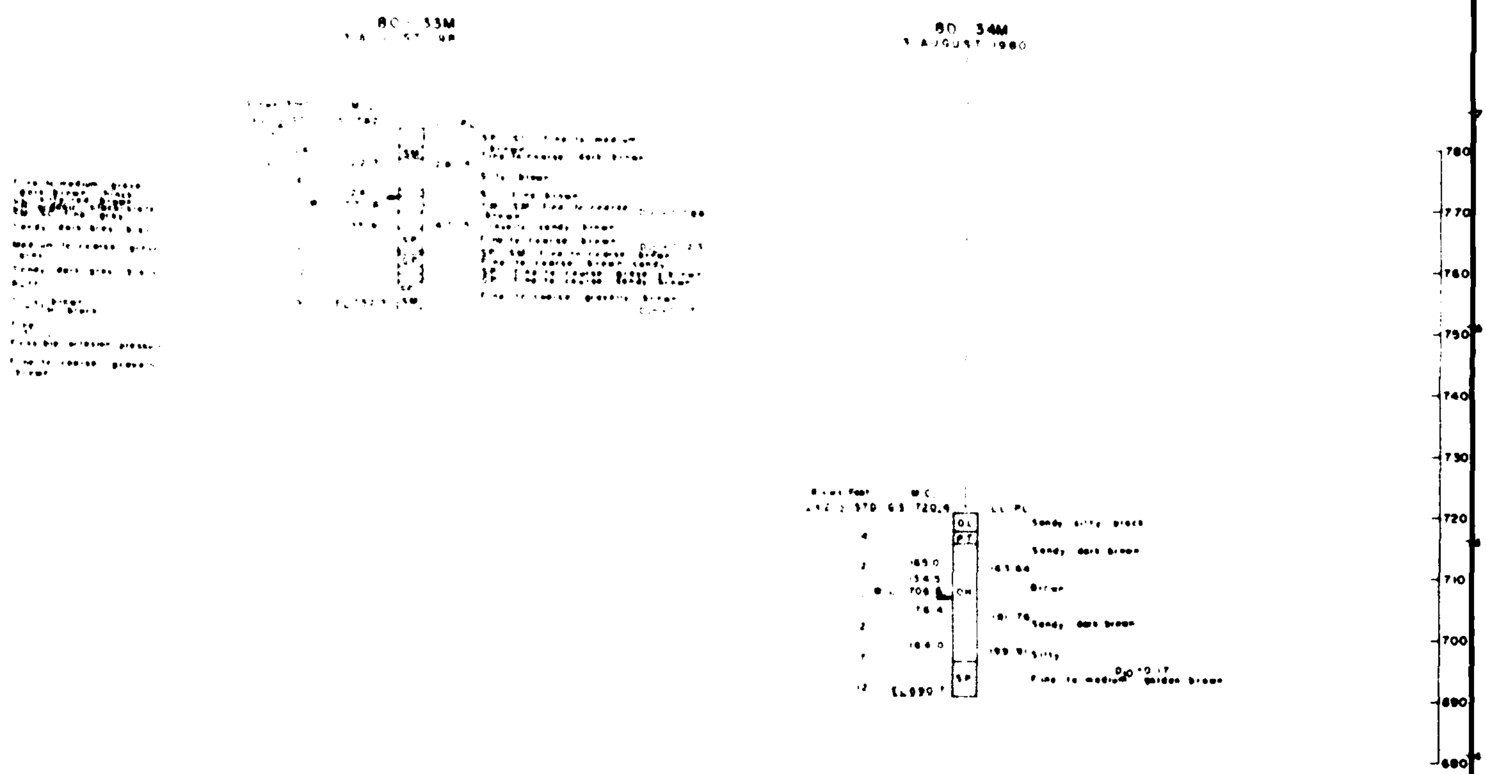
BORING LOGS
80 - 25M THRU 80 - 30M

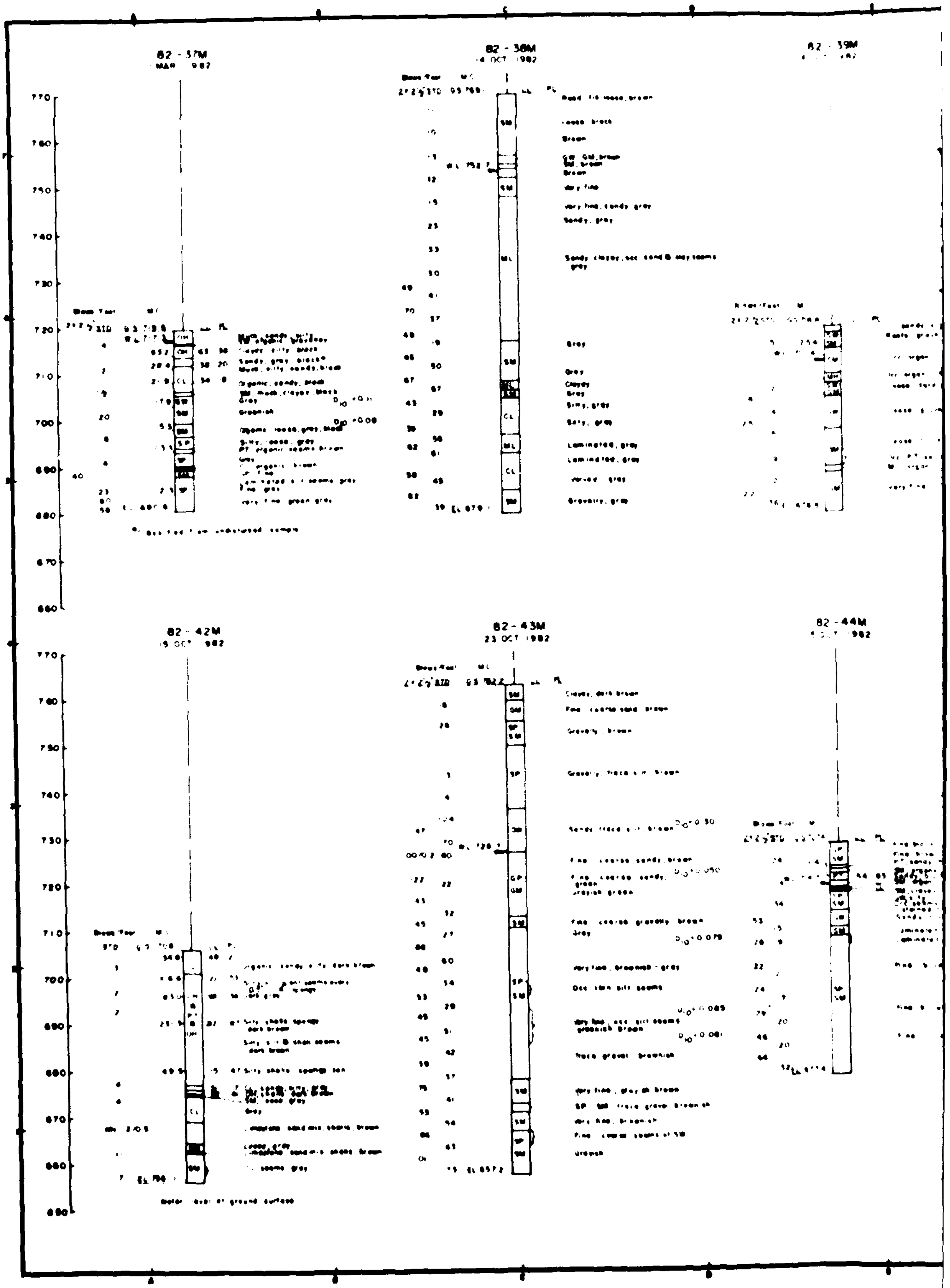
MARCH 1984

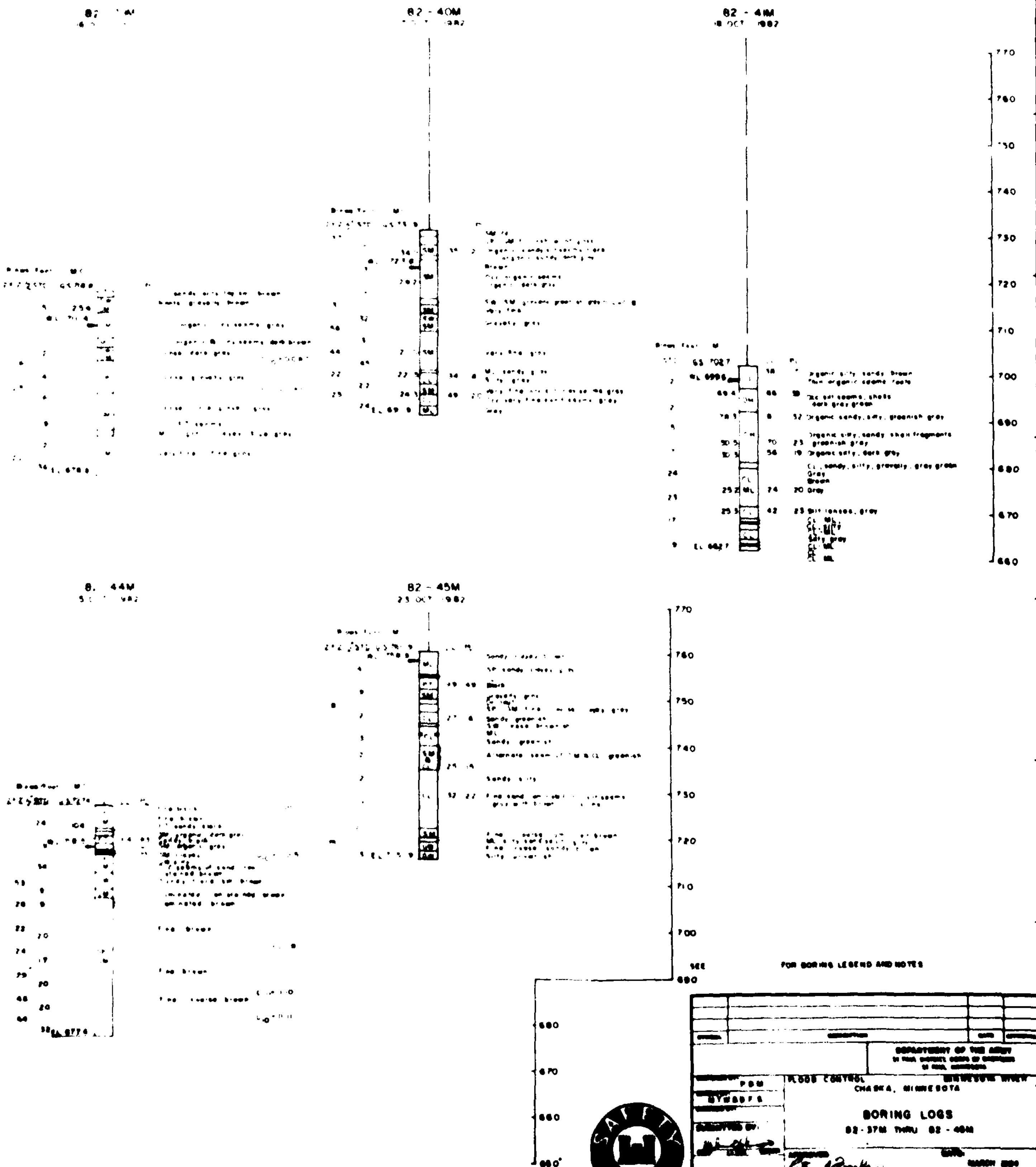
M34-CH-9-8/71

PLATE C-8


80-31M
12 AUGUST 1980
80-32M
780
770
760
750
740
730
720
710
700
690
680


BO-33M
BO 34M
AUGUST 1980
720.4
OL
PT
CH
SP
Sandy silty black
Sandy dark brown
Brown
Sandy dark brown
Silty
Fine to medium golden brown
780
770
760
750
740
730
720
710
700
690
680


82 - 37M
82 - 38M
82 - 39M
82 - 42M
82 - 43M
23 OCT 1982
82 - 44M



SEE FOR BORING LEGEND AND NOTES

DEPARTMENT OF THE ARMY

FLOOD CONTROL MINNESOTA RIVER

CHASKA, MINNESOTA

PDM

BYWAGERS

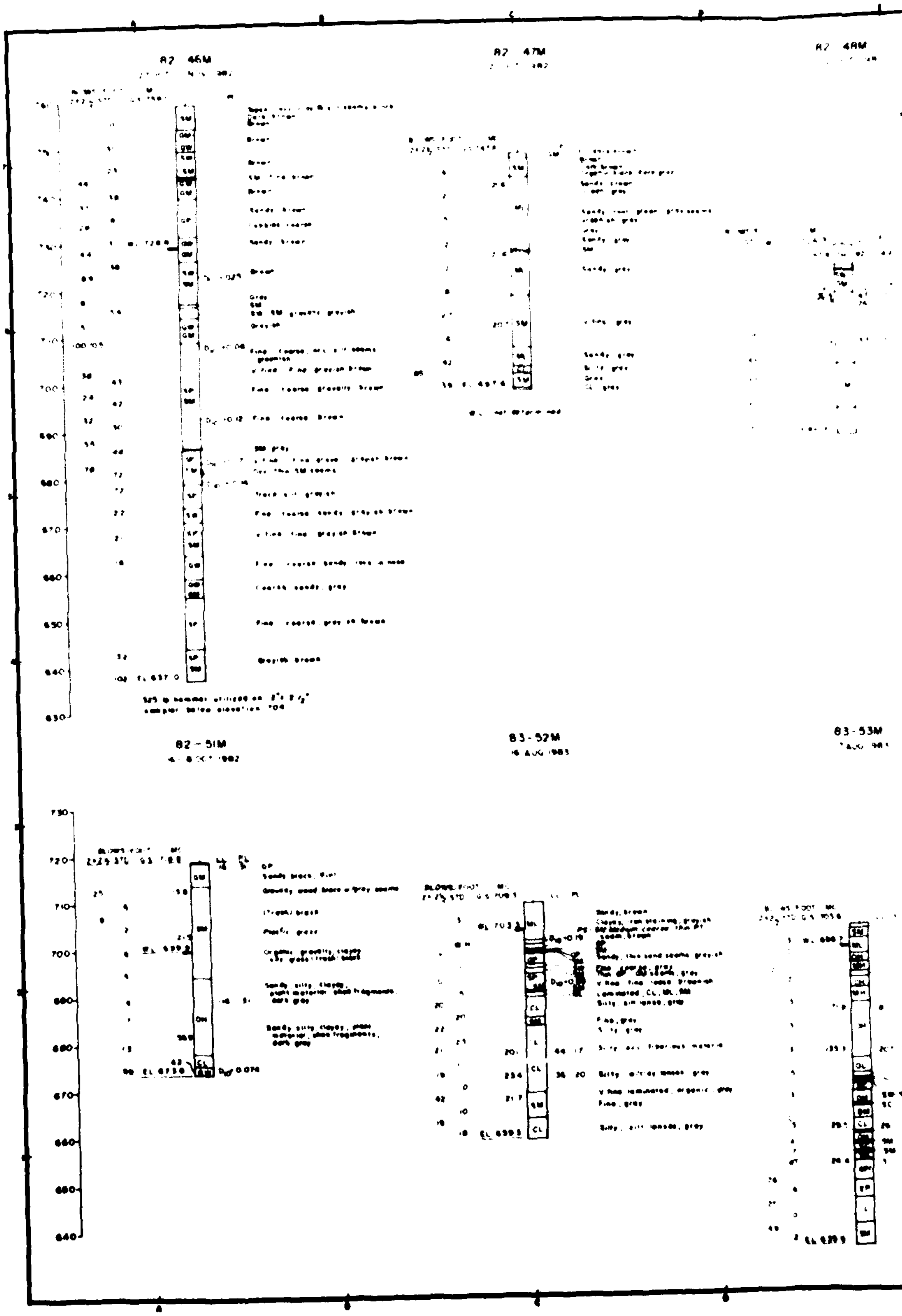
BORING LOGS

82-37M THRU 82-46M

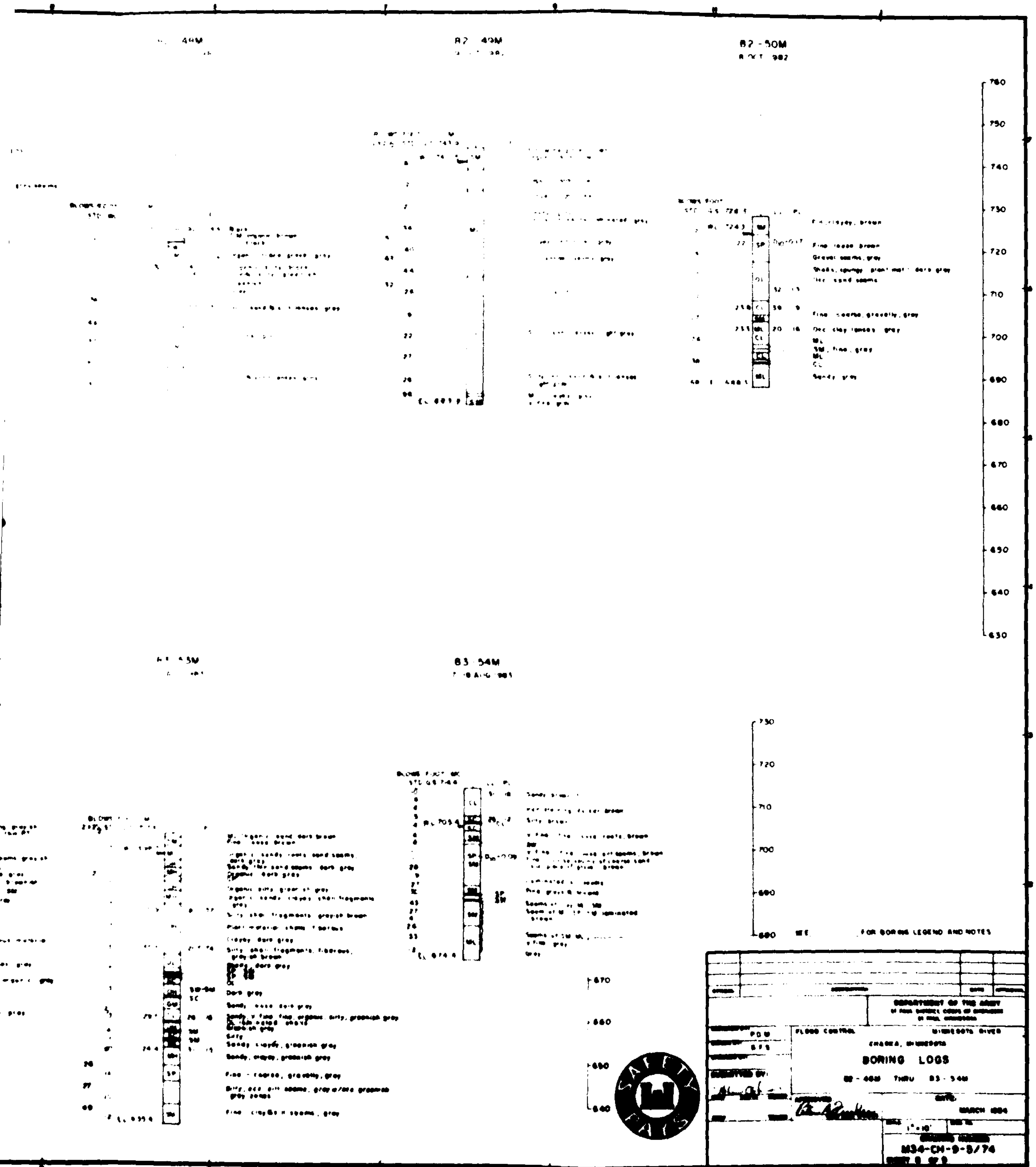
1"=10'

M34-CH-9-5/73

PLATE C-7

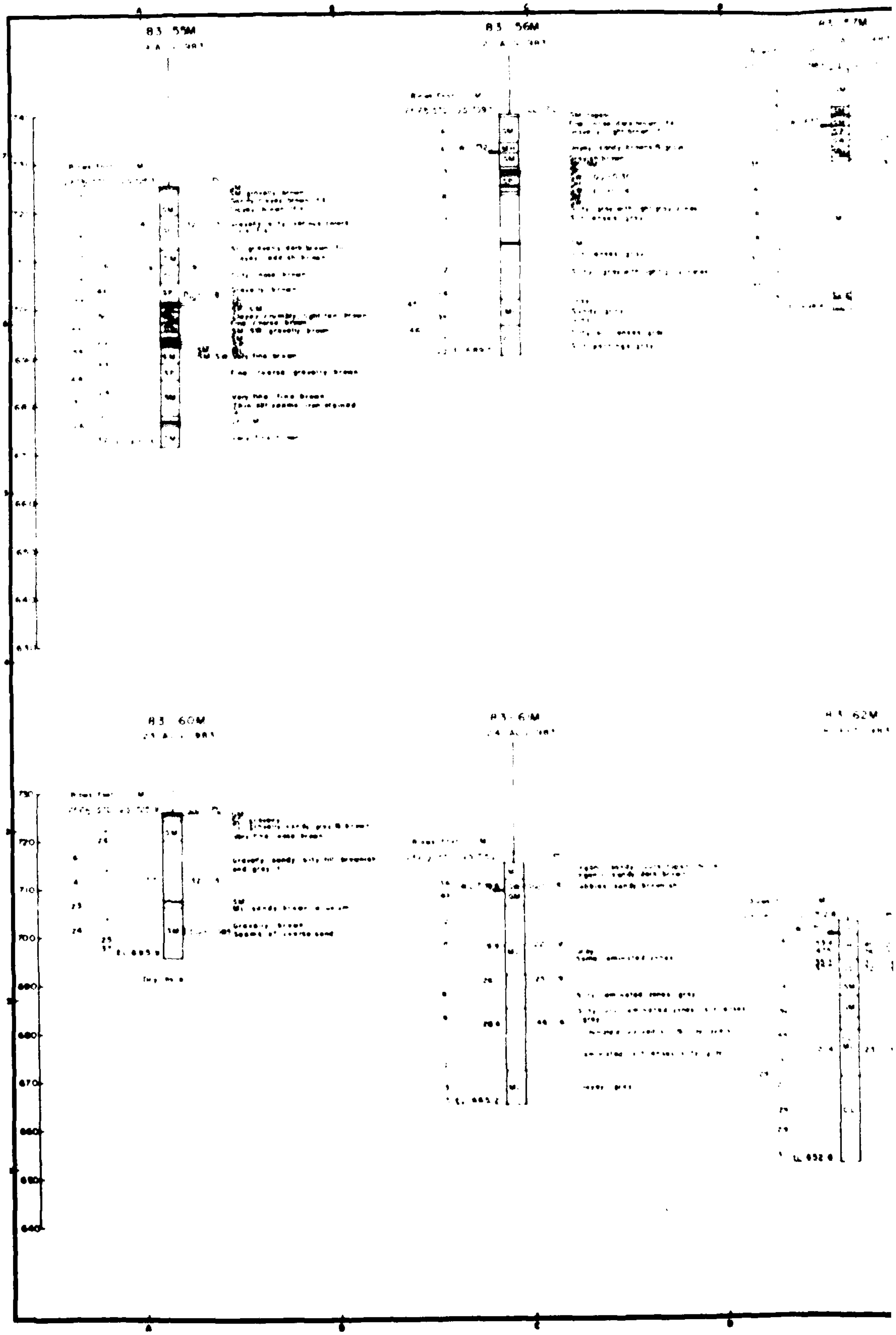


82 - 46M
82 - 47M
82 - 48M
82 - 51M
83 - 52M
16 AUG 1983
83 - 53M

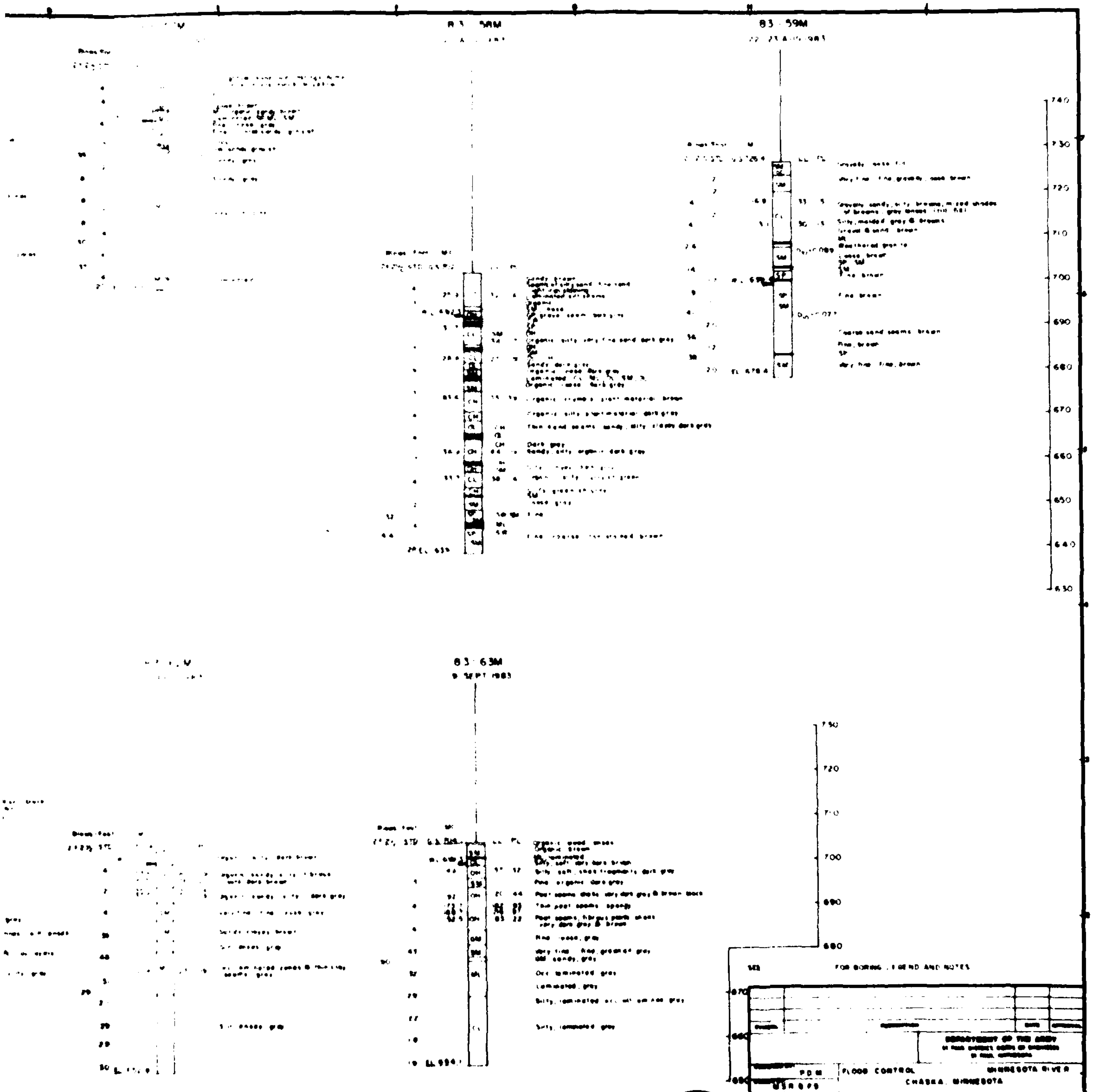


B2 - 49M
B2 - 50M
8 OCT 1982
B3 - 54M
760
750
740
730
720
710
700
690
680
670
660
650
640
630
Fine, loose, brown
Gravel seams, gray
Sandy, gray
FOR BORING LEGEND AND NOTES
DEPARTMENT OF THE ARMY
FLOOD CONTROL
MINNESOTA RIVER
CHASKA, MINNESOTA
BORING LOGS
B2 - 48M THRU B3 - 54M
MARCH 1984
1" = 10'
M34-CH-9-8/74

PLATE C-8



83-55M
83-56M
83-60M
83-61M
83-62M
730
720
710
700
690
680
670
660
650
640



DEPARTMENT OF THE ARMY

FLOOD CONTROL MINNESOTA RIVER

CHASKA, MINNESOTA

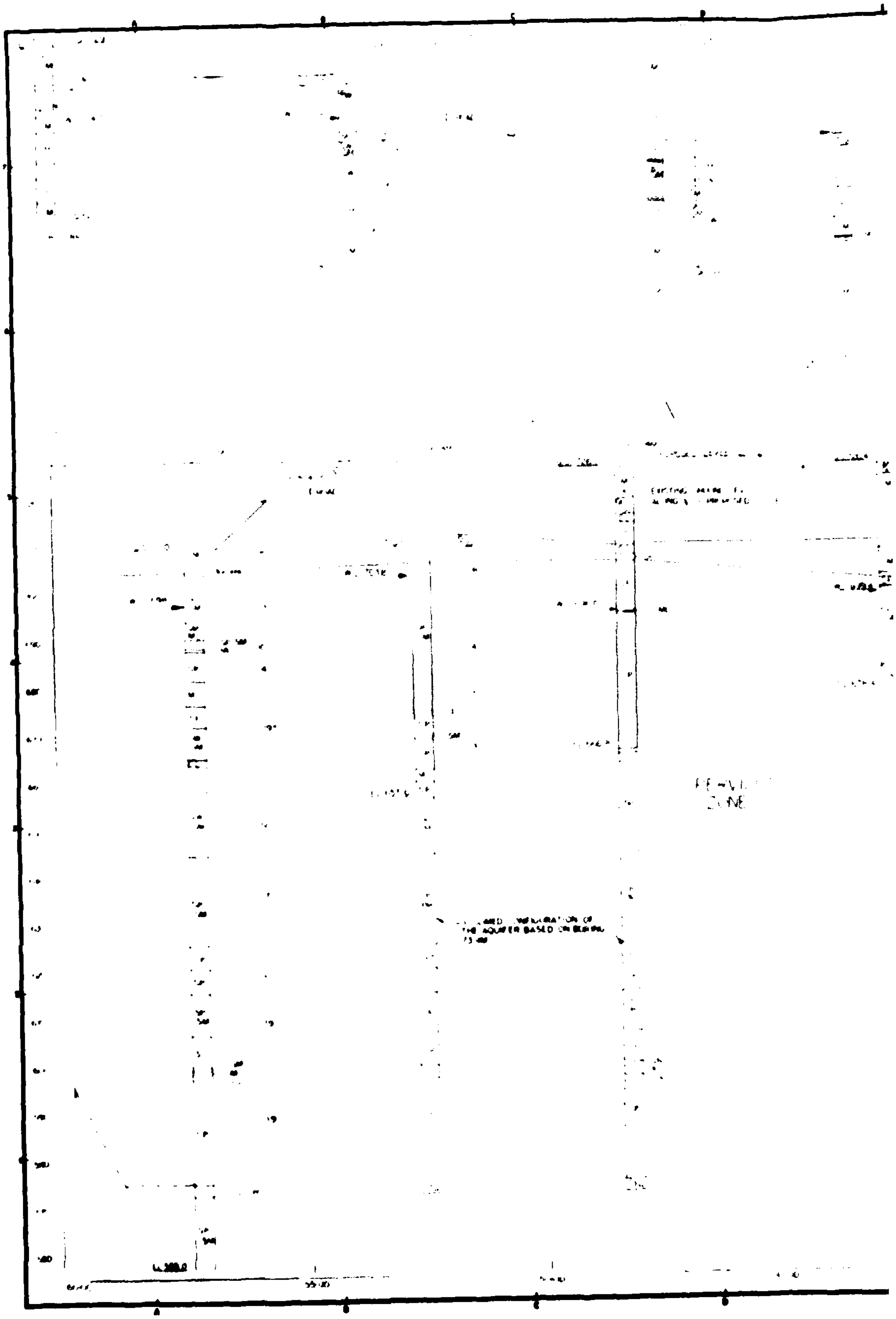
BORING LOGS

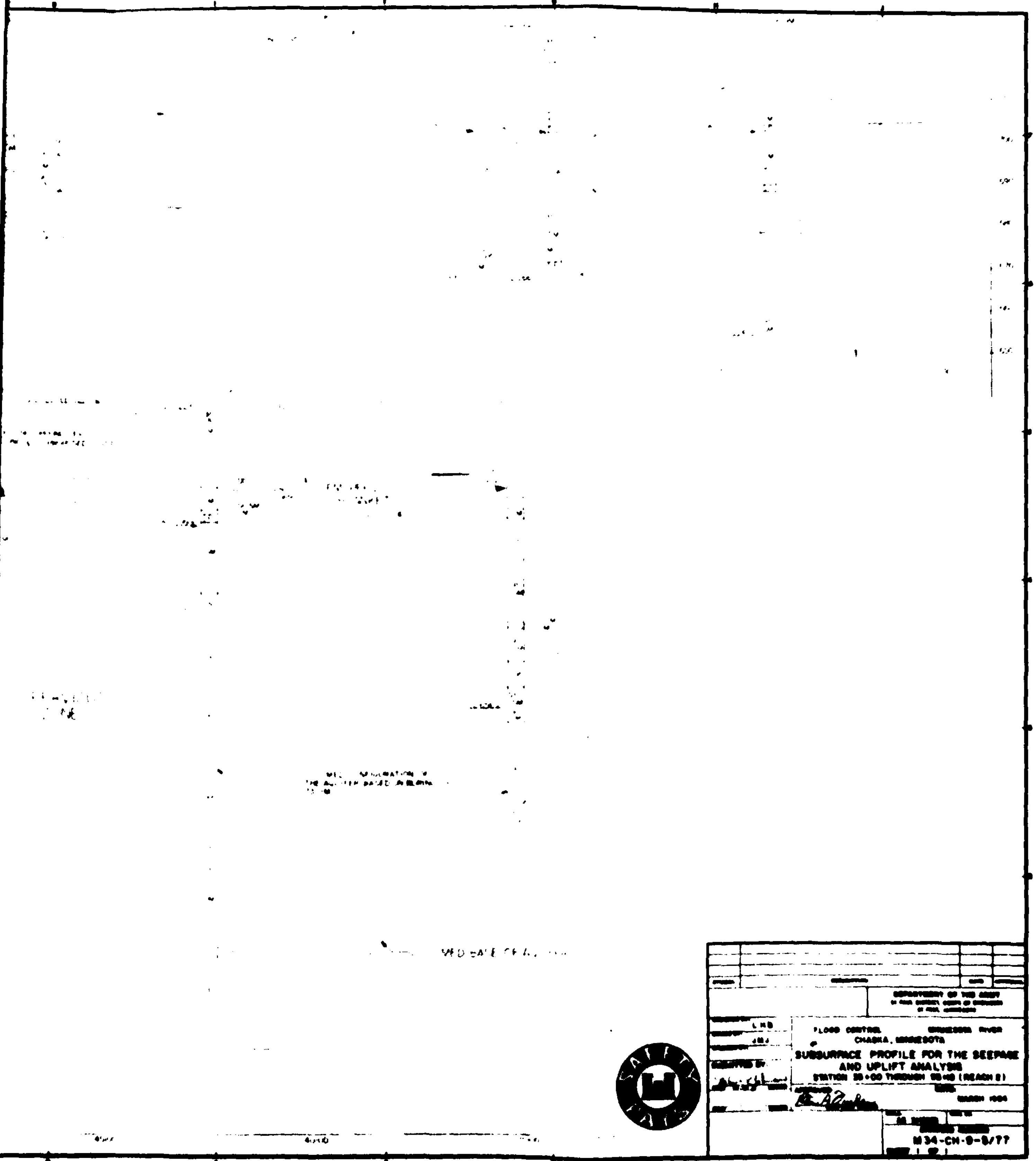
83-58M THRU 83-63M

MARCH 1984

M34-CH-9-9/75

PLATE C-9


THE AQUIFER BASED



DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

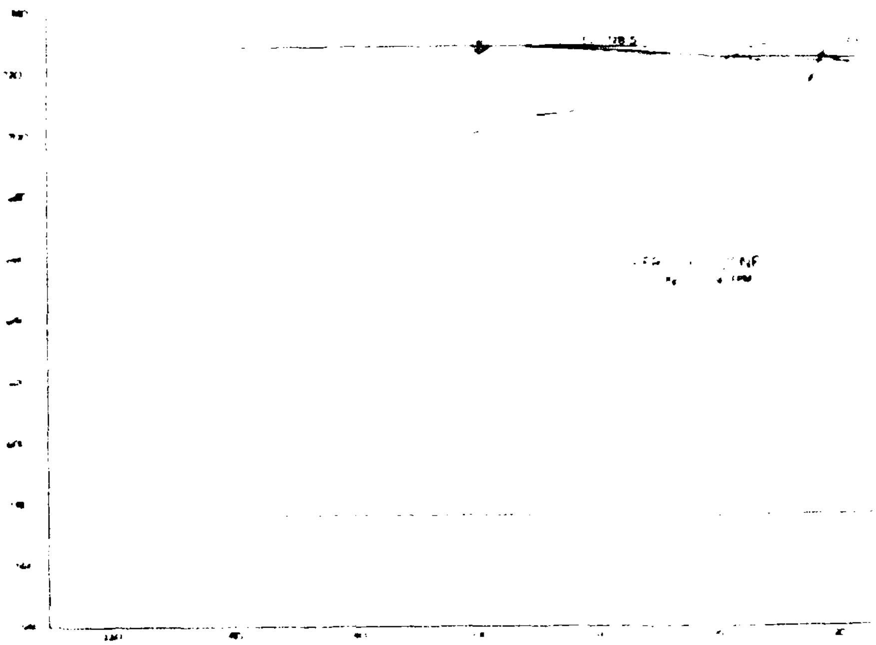
FLOOD CONTROL MINNESOTA RIVER
CHASKA, MINNESOTA

SUBSURFACE PROFILE FOR THE SEEPAGE AND UPLIFT ANALYSIS
STATION 35+00 THROUGH 55+10 (REACH 2)

MARCH 1984

M34-CH-9-8/77

PLATE C-10



UPLIFT COMPUTATION

BLANKET TRANSFORMATION

STRATA	ACTUAL THICKNESS (FT)	ACTUAL PERMEABILITY (FPM)	TRANSFORMATION FACTOR	TRANSFORMED THICKNESS (FT) FOR k_{bl} = 0.0008 FPM
SILTY SAND (SM)	2.0	0.0020	[illegible]	[illegible]
[illegible]	3.0	0.0008	[illegible]	3.0
	Z_t = 5.0 FT			Z_{bl} = 3.8 FT

PERVIOUS TRANSFORMATION

STRATA	(d) THICKNESS (FT)	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SP	[illegible]	0.14	[illegible]	0.862
SP	[illegible]	0.14	0.092	0.377
[illegible]	[illegible]	0.099	0.083	0.361
[illegible]	9.5	0.13	0.086	1.287
[illegible]	9.5	0.17	0.14	2.660
SP	19.0	0.21	0.22	4.180
[illegible]	9.0	0.19	0.18	1.620
SP	22.0	0.12	0.066	492
	Σd = [illegible] FT			[illegible] = 12.608

$k_f = \frac{\Sigma k_f d}{d}$ [illegible]

$x_3 = \sqrt{c} = 244.4$ FT

FROM THE CROSS SECTION

[illegible] AT ELEVATION 710.0

[illegible] 25 FT $\quad L_2$ = 185 FT $\quad L_3$ = ∞ $\quad x_3$ = 244.4 FT

CASE 7 [illegible] TOP STRATA BOTH SIDES

TOP OF LEVEE ELEVATION = 728.5 $\quad$ DESIGN FLOOD ELEVATION = 725.5

H (FOR UPLIFT) = 725.5 − 710.0 = 15.5 FT $\quad$ H (FOR SEEPAGE) = 725.5 − 710 = 15.5 FT

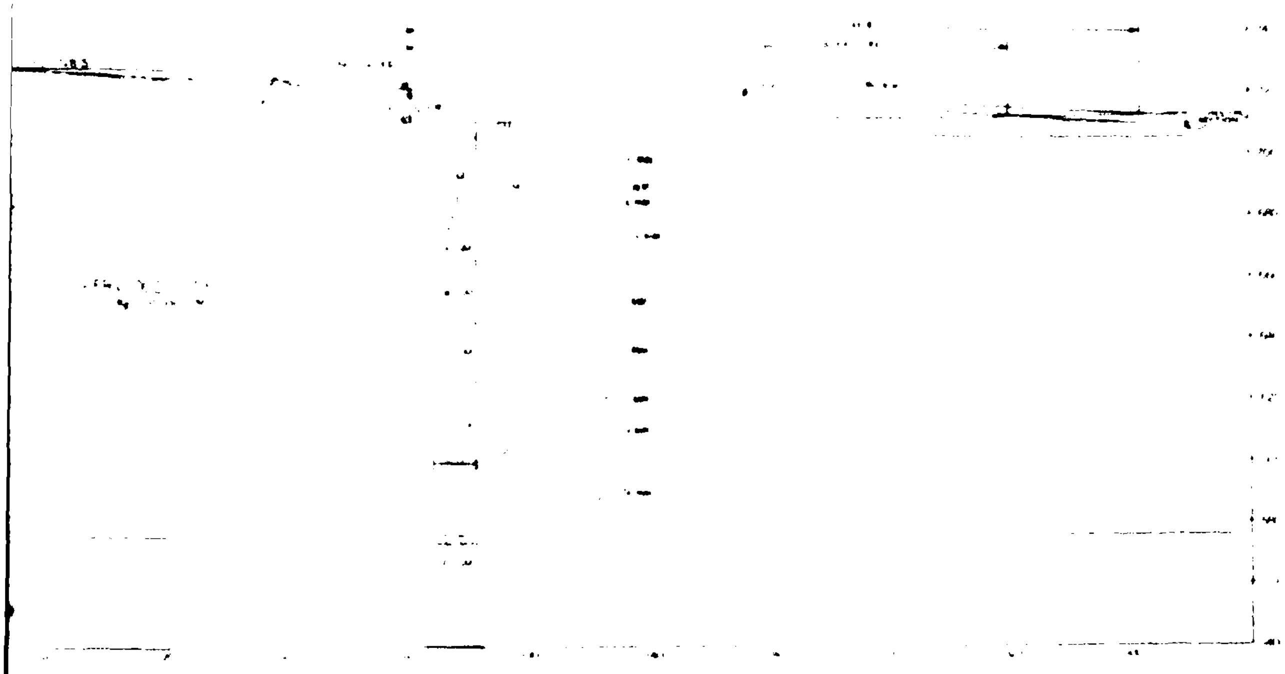
x_1 = [illegible] = 24.9 FT

$S = \frac{Sd}{x_1 + L_2 + x_3} = \frac{15.5}{24.9 + 185 + 244.4} = 0.298$

$h_0 = H\left[\frac{x_3}{x_1 + L_2 + x_3}\right] = 15.5\left[\frac{244.4}{24.9 + 185 + 244.4}\right]$ = [illegible] FT

FS (for UPLIFT) = [illegible] = 0.43

$Q_s = k_f\,S\,H$ = 0.106 × 0.298 × 15.5 × 7.48 [illegible] = 3.60 GPM / FT OF LEVEE



BERM DESIGN

RELIEF WELLS

RECOMMENDED BERM DESIGN FOR SECTION 6:

	SEMIPERVIOUS BERM	SAND BERM
DISTANCE FROM LEVEE TOE TO [illegible] OF BERM	340 FT	335 FT
BERM SLOPE	[illegible]	[illegible]
THICKNESS AT LEVEE TOE (INCREASED 20%)	[illegible] FT	8.0 FT

THESE BERMS [illegible] LARGE REAL ESTATE ACQUISITION [illegible] RELIEF WELLS SHOULD BE CONSIDERED THOUGH THIS REACH [illegible] SLOPES UP BEHIND THE LEVEE BEFORE THE [illegible] SEEPAGE DISTANCE (x_3) [illegible] BE OBTAINED, THE POINT AT WHICH THE HYDRAULIC GRADE LINE INTERSECTS THE ACTUAL GROUND SURFACE HAS BEEN ASSUMED TO BE A SEEPAGE BERM. THIS RESULTS IN A HIGHER HEAD AT THE LEVEE TOE (h_0) THAN THE CLASSICAL METHOD AND THUS THIS HEAD WILL BE USED TO DESIGN THE RELIEF WELLS [illegible] THE [illegible] OF THE [illegible] UNDER DESIGN CONDITIONS [illegible] SHOWN GRAPHICALLY IN THE SECTION ABOVE

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

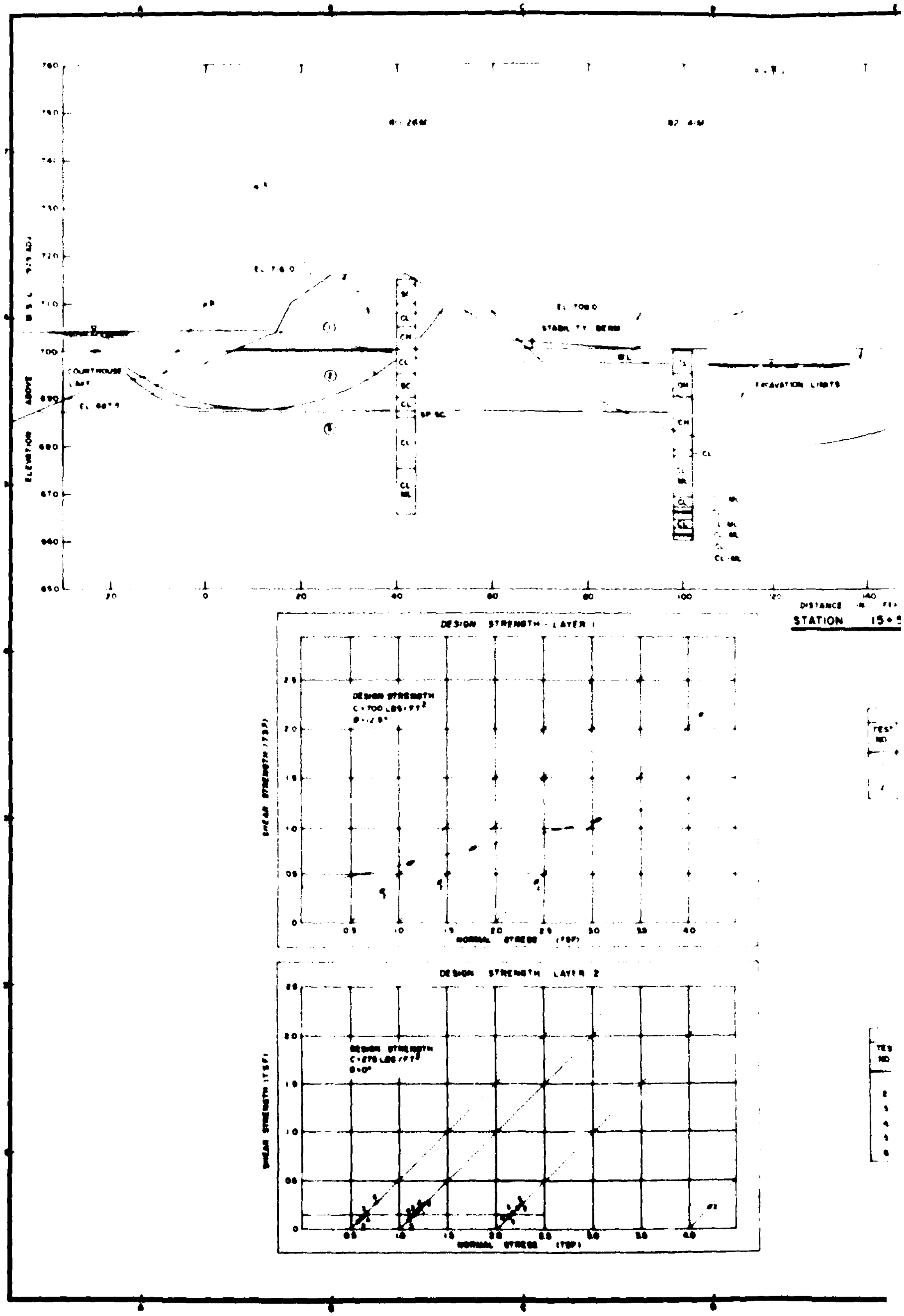
FLOOD CONTROL — MINNESOTA RIVER

CHASKA, MINNESOTA
SEEPAGE AND UPLIFT
TYPICAL COMPUTATIONS

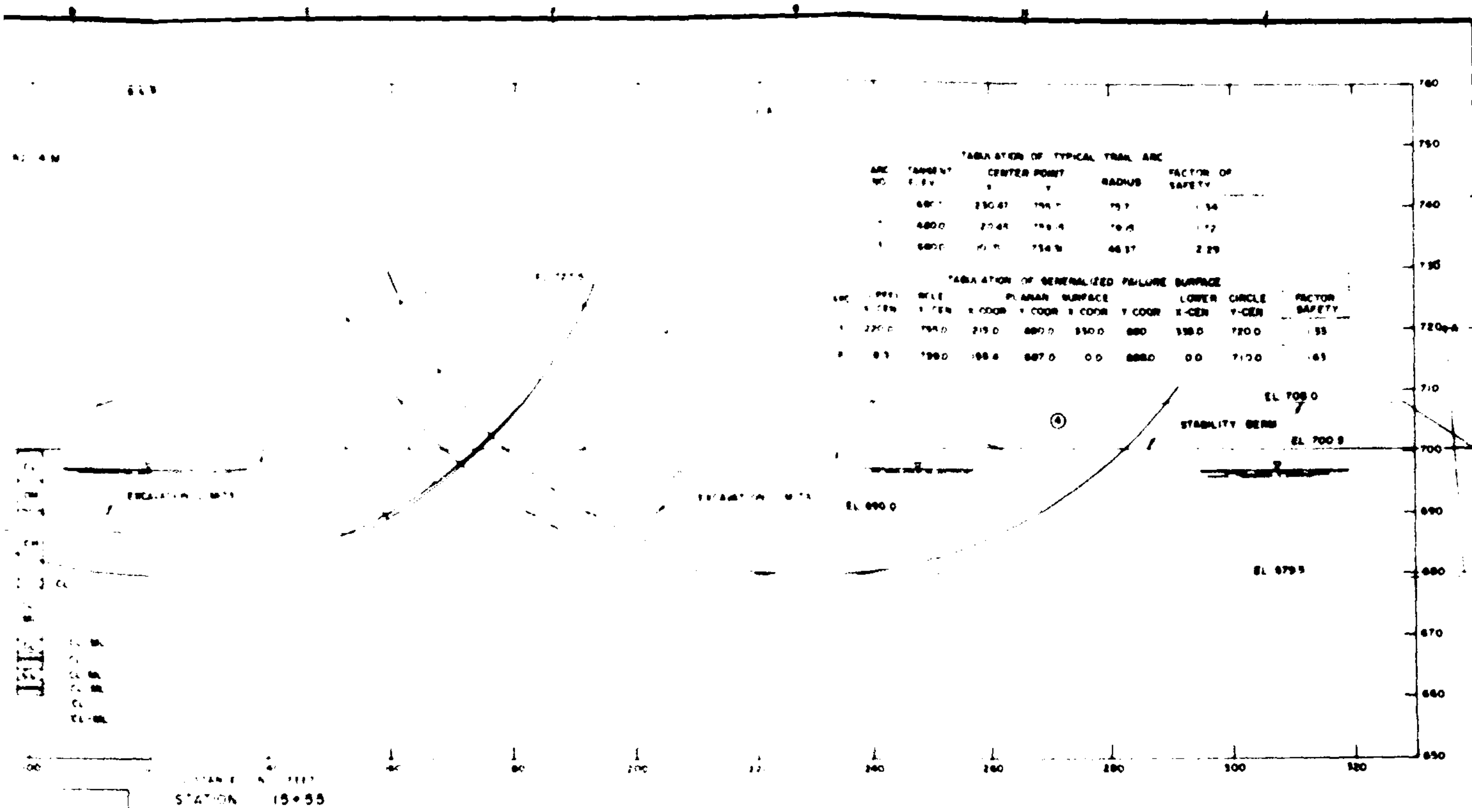
MARCH 1984

M34-CH-9-6/78

PLATE C-11



ELEVATION
ABOVE
COURTHOUSE
EXCAVATION LIMITS
DISTANCE
STATION
DESIGN STRENGTH - LAYER 1
DESIGN STRENGTH
SHEAR STRENGTH (TSF)
NORMAL STRESS (TSF)
DESIGN STRENGTH LAYER 2
DESIGN STRENGTH
SHEAR STRENGTH (TSF)
NORMAL STRESS (TSF)



TABULATION OF TYPICAL TRIAL ARC

ARC NO.	TANGENT ELEV.	CENTER POINT X	CENTER POINT Y	RADIUS	FACTOR OF SAFETY
[illegible]	680.[illegible]	230.47	755.[illegible]	75.[illegible]	1.34
[illegible]	680.0	22.45	75[illegible].4	76.[illegible]	1.72
[illegible]	680.0	[illegible]	754.[illegible]	46.37	2.29

TABULATION OF GENERALIZED FAILURE SURFACE

ARC	UPPER CIRCLE X-CEN	UPPER CIRCLE Y-CEN	PLANAR SURFACE X COOR	PLANAR SURFACE Y COOR	PLANAR SURFACE X COOR	PLANAR SURFACE Y COOR	LOWER CIRCLE X-CEN	LOWER CIRCLE Y-CEN	FACTOR SAFETY
1	220.0	755.0	215.0	680.0	350.0	680	350.0	720.0	1.35
2	0.3	790.0	198.4	687.0	0.0	688.0	0.0	712.0	1.65

UNCONSOLIDATED UNDRAINED (Q TEST)

TEST NO.	BORING NO.	LIQUID LIMIT	PLASTIC LIMIT	WATER CONTENT %	DRY DENSITY lb/ft³	VOID RATIO	SATURATION %
[illegible]	8[illegible]-[illegible]	34	[illegible]	[illegible]	[illegible]	0.84	65.0
[illegible]	83-[illegible]	31	[illegible]	14	116.70	0.47	77.0

SOIL CONSTANTS				
TYPE NO	WT MOIST lb/ft³	WT SAT lb/ft³	C (1) lb/ft²	Ø (1) DEG
1	123.0	134.0	700.0	12.5
2	95.2	95.2	275.0	0
3	132.0	132.0	9000.0	0
4	95.0	95.0	100.0	0

NOTE:
LAB DATA FOR SOIL TYPE NO. 3 IS FROM BORING 81-[illegible] SAMPLE NO. [illegible]

UNCONSOLIDATED UNDRAINED (Q TEST)

TEST NO.	BORING NO.	LIQUID LIMIT	PLASTIC LIMIT	WATER CONTENT %	DRY DENSITY lb/ft³	VOID RATIO	SATURATION %
[illegible]	85-[illegible]	80	70	56.4	66.2	1.64	96.7
2	85-[illegible]	51	14	35.5	87.0	0.91	100
3	86-[illegible]	182	56	173.7	27.8	4.05	100
4	86-[illegible]	88	30	69.4	58.9	1.71	100
5	87-[illegible]	91	32	76.3	55.4	2.04	100
6	87-[illegible]	116	31	74.6	54.0	1.88	100

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

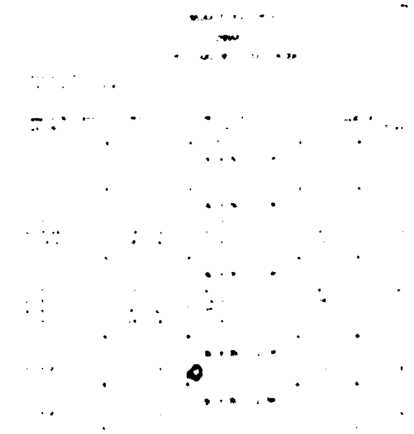
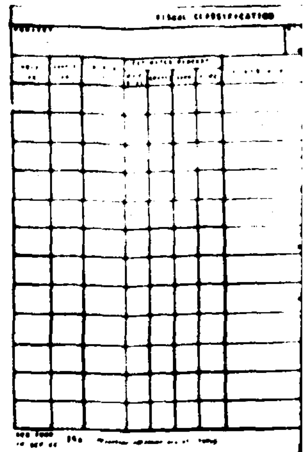
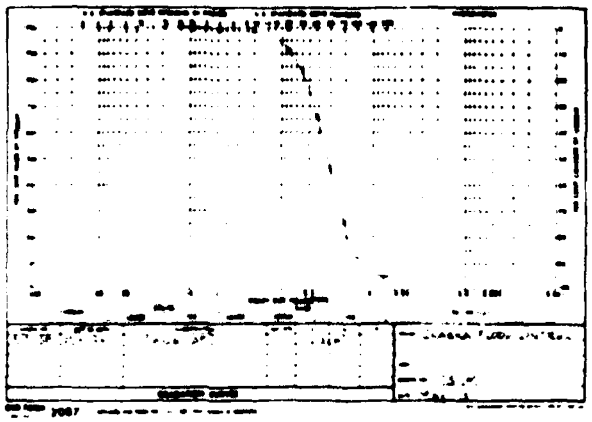
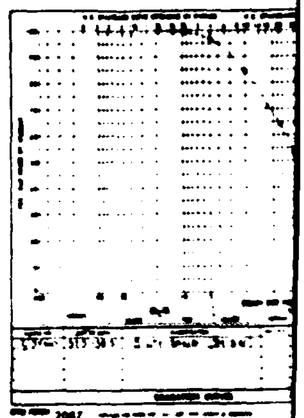
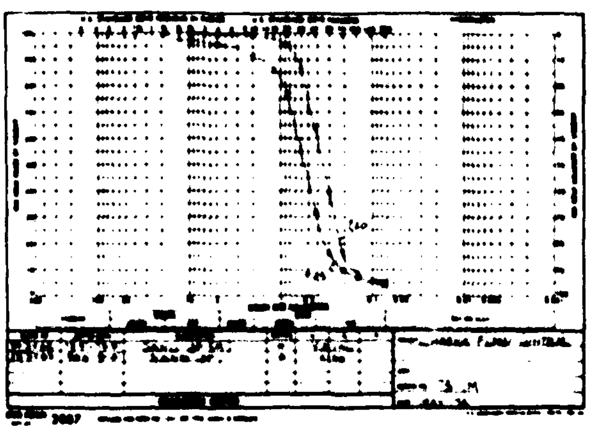
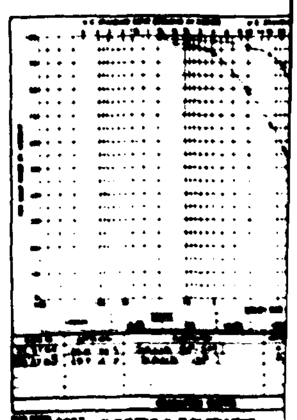
CHASKA FLOOD CONTROL CHASKA, MINNESOTA
SLOPE STABILITY ANALYSIS
END OF CONSTRUCTION CASE
STATION 15+55

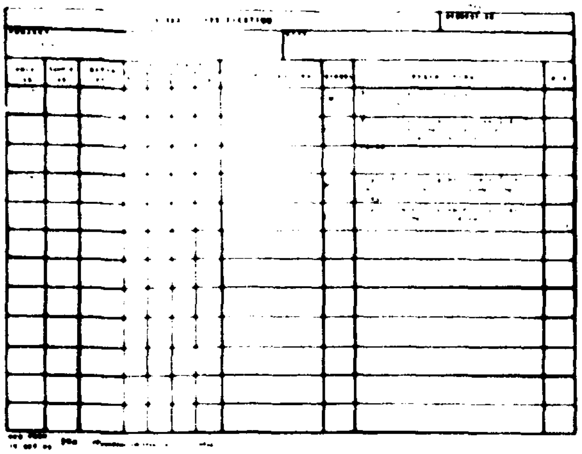
MARCH 1984

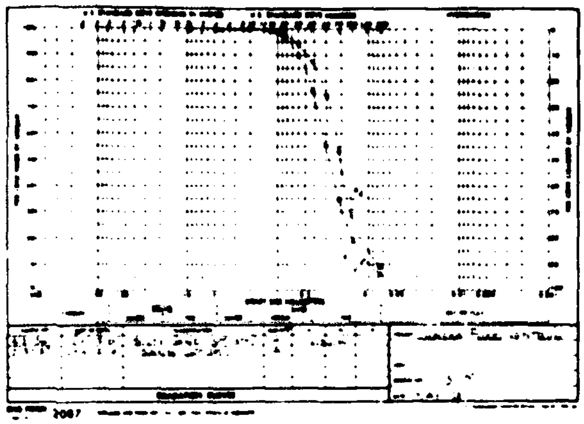
AS SHOWN

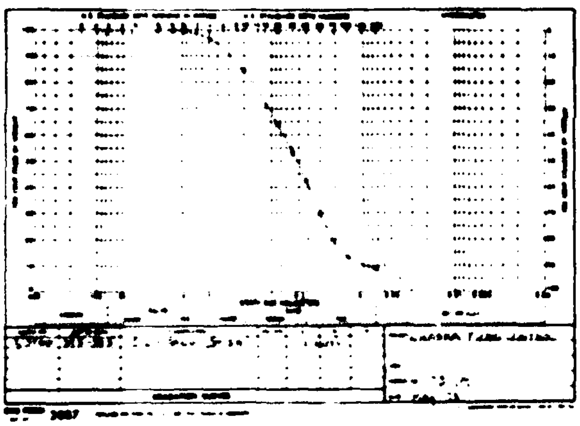
M34-CH-9-8/79

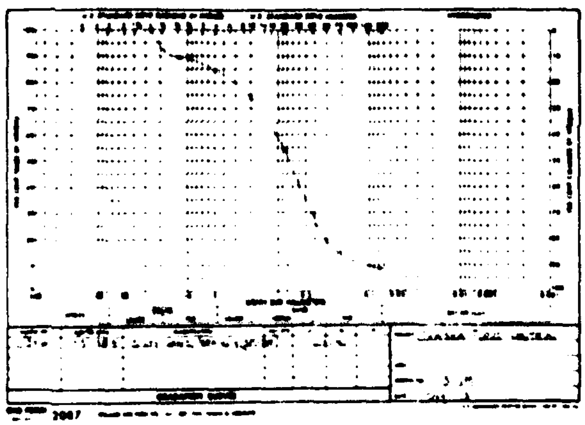
PLATE C-12

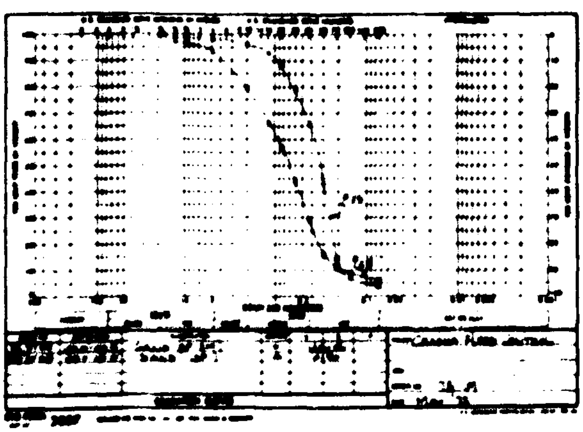

















PDB

AMJ

FLOOD CONTROL MINNESOTA RIVER
CHASKA, MINNESOTA

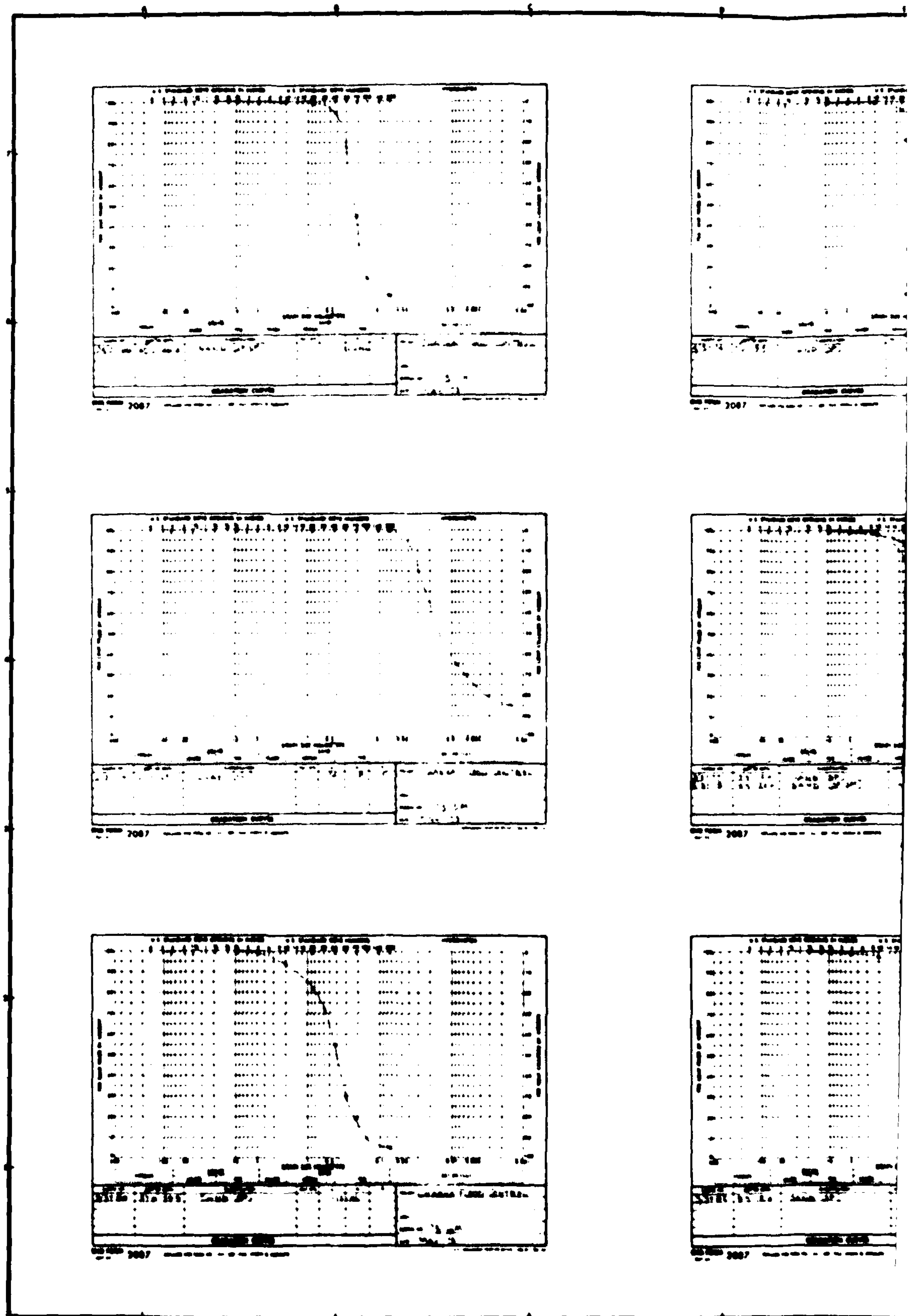
1973 LABORATORY TESTS

BORINGS 73-[illegible] TO 73-7U

MARCH 1984

M34-CH-9-3/80

PLATE C-13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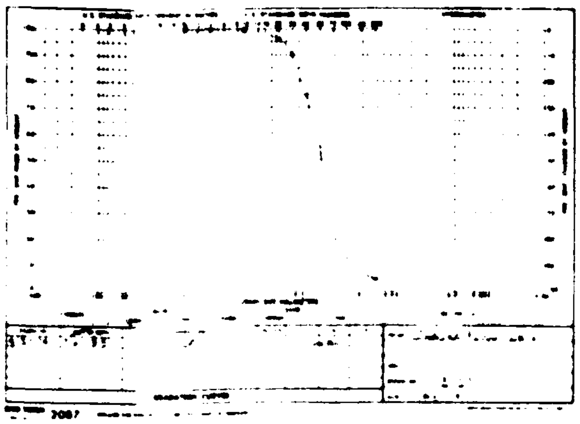
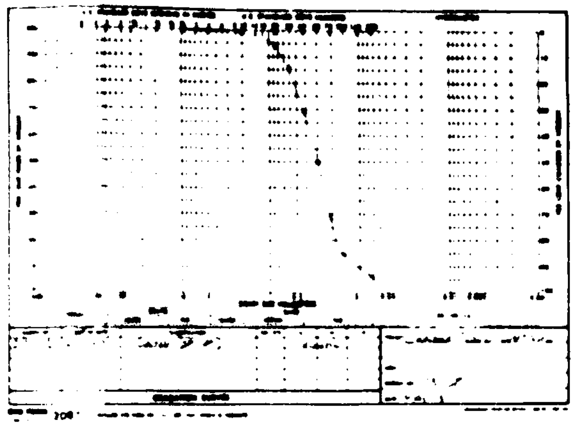
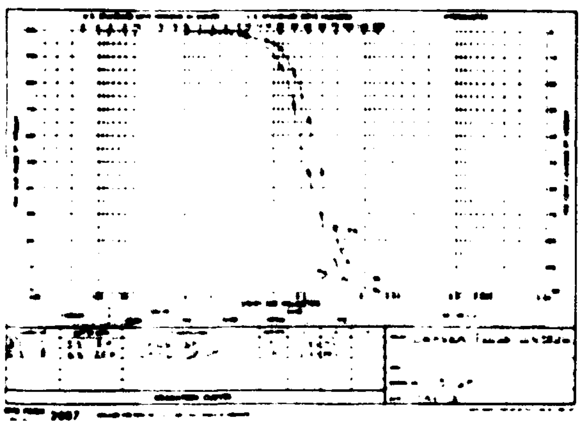
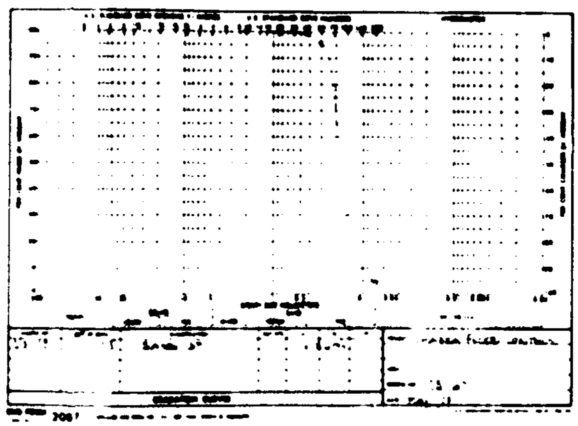
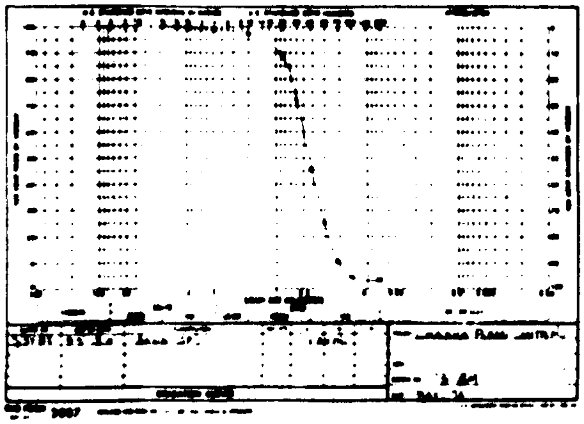










DEPARTMENT OF THE ARMY

FLOOD CONTROL MINNESOTA RIVER

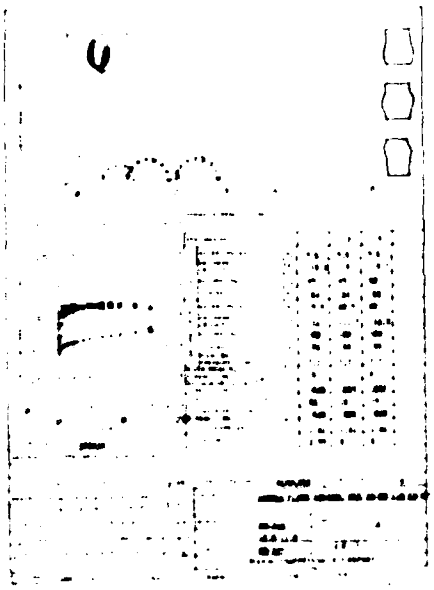
CHASKA, MINNESOTA

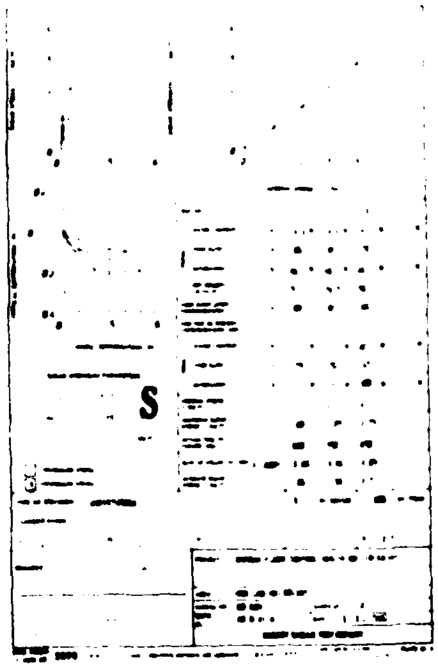
1973 LABORATORY TESTS

BORING 73-18 TO 73-[illegible]

M34-CH-9-5/61

PLATE C-14

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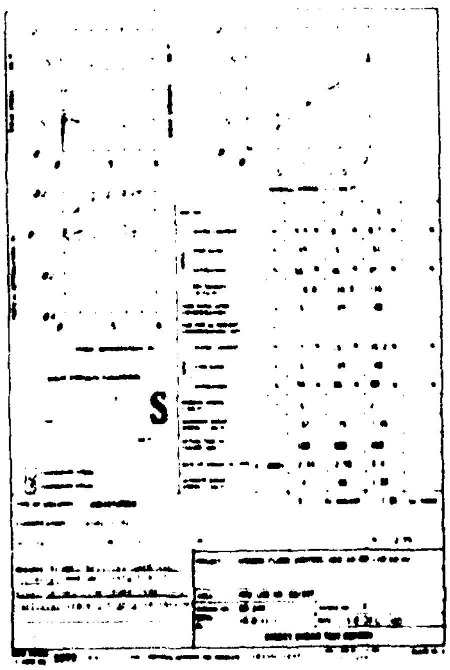
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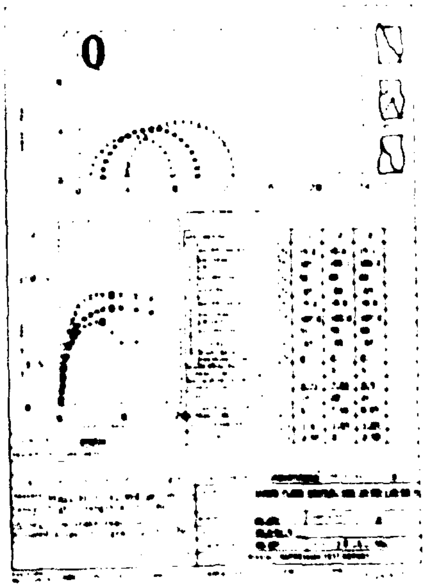
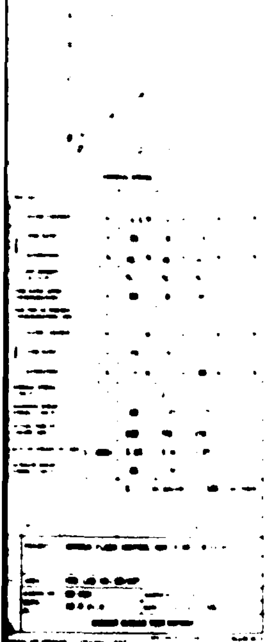
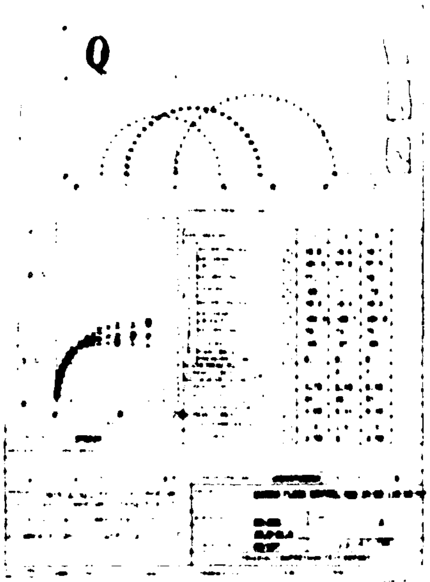
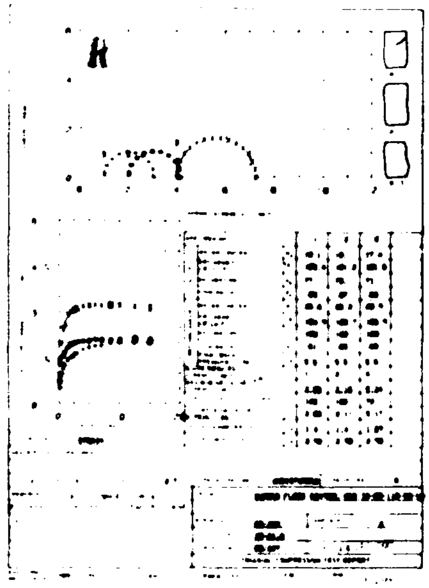
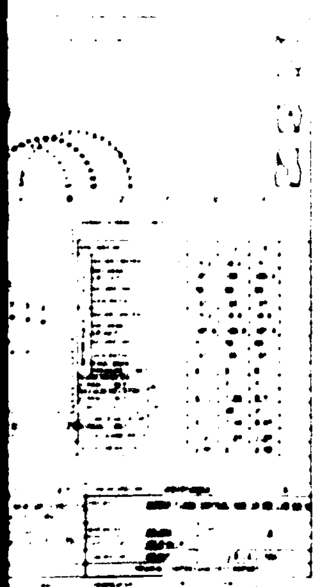










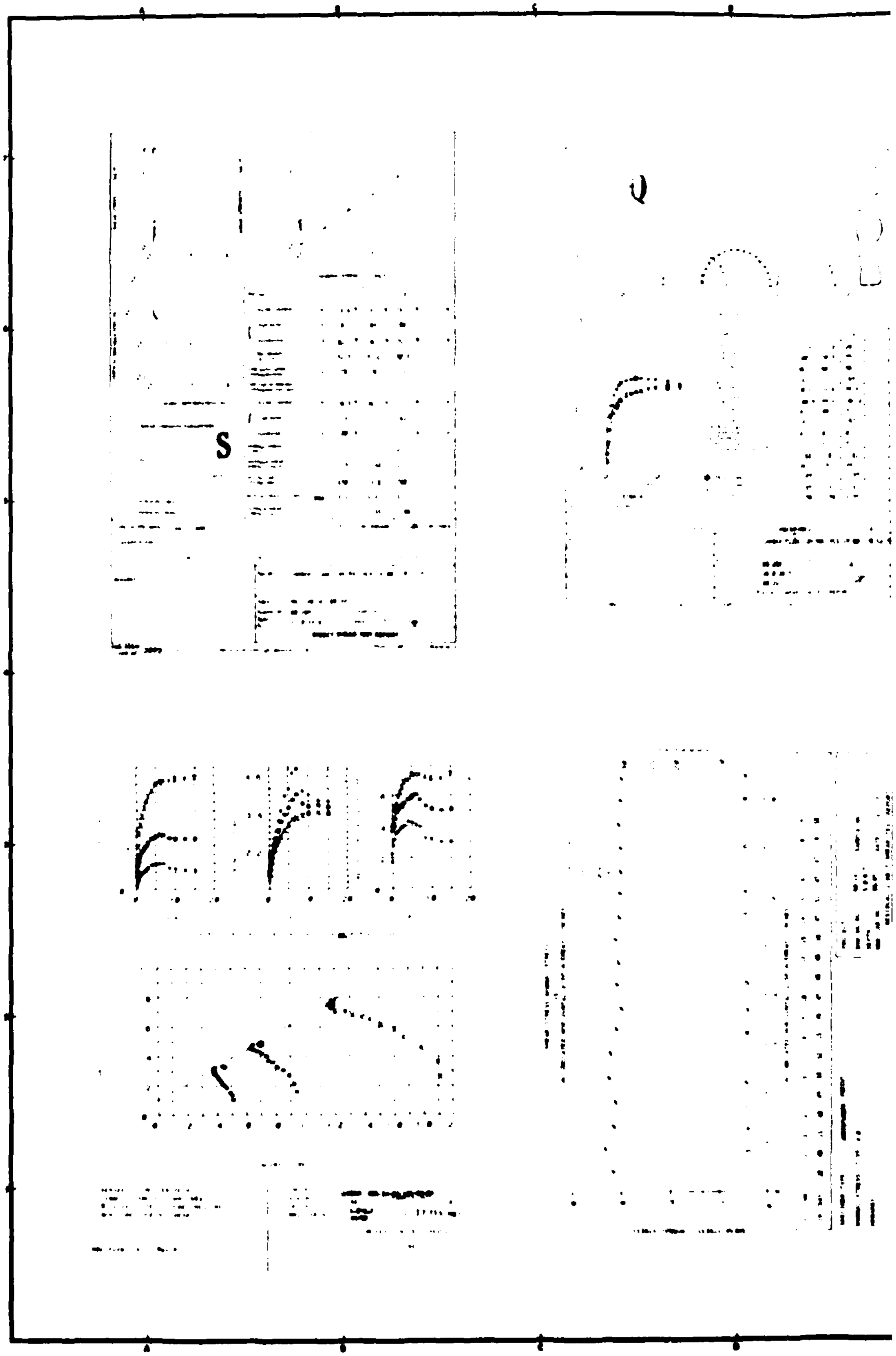
DEPARTMENT OF THE ARMY

FLOOD CONTROL MINNESOTA RIVER

CHASKA, MINNESOTA

TRIAXIAL TESTS

PLATE C-1[illegible]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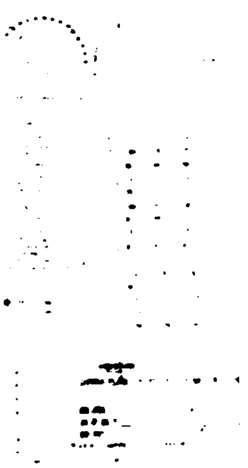
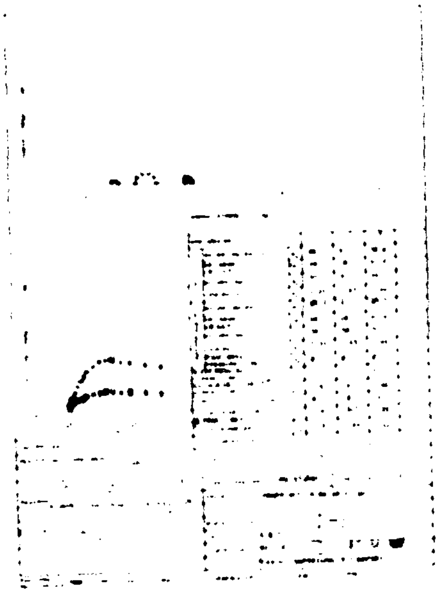
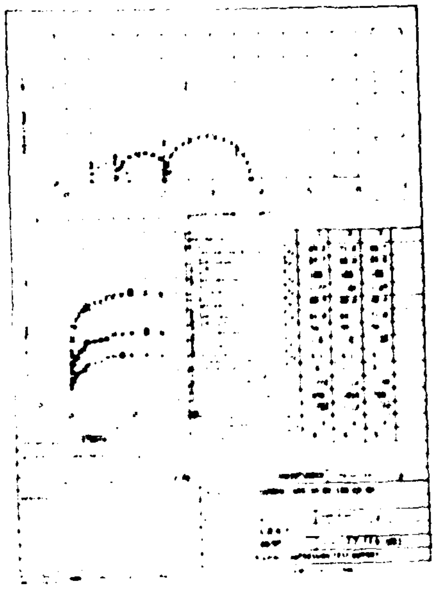
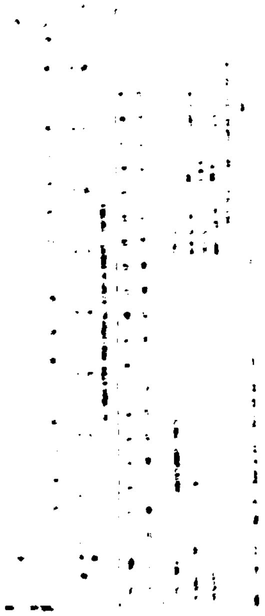
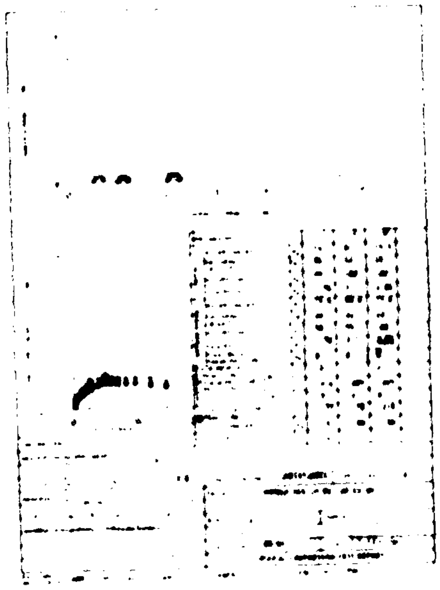










DEPARTMENT OF THE ARMY

FLOOD CONTROL MINNESOTA RIVER

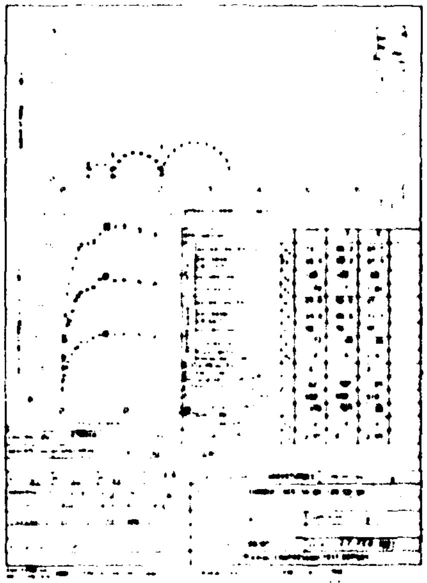
CHASKA, MINNESOTA

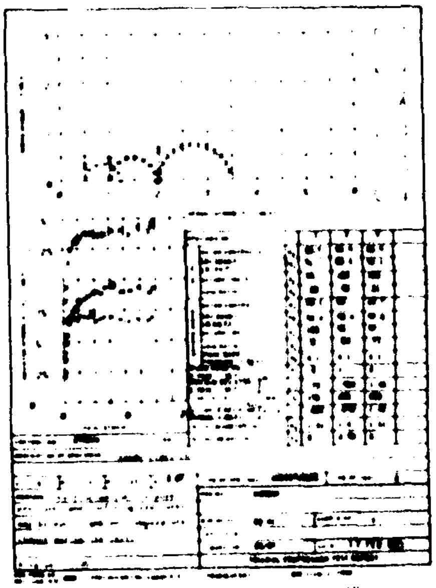
TRIAXIAL TESTS

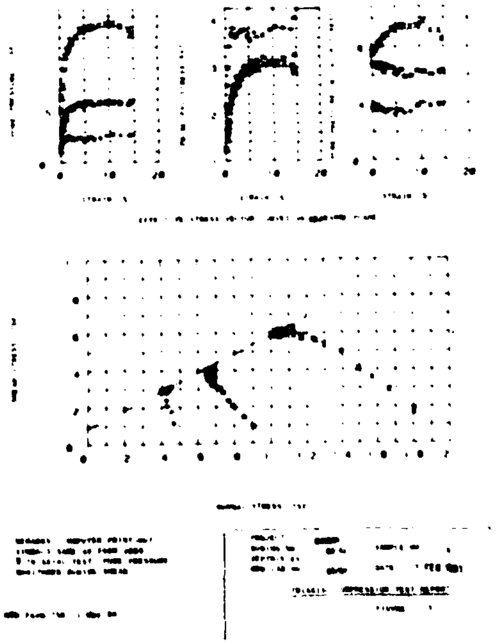
MARCH

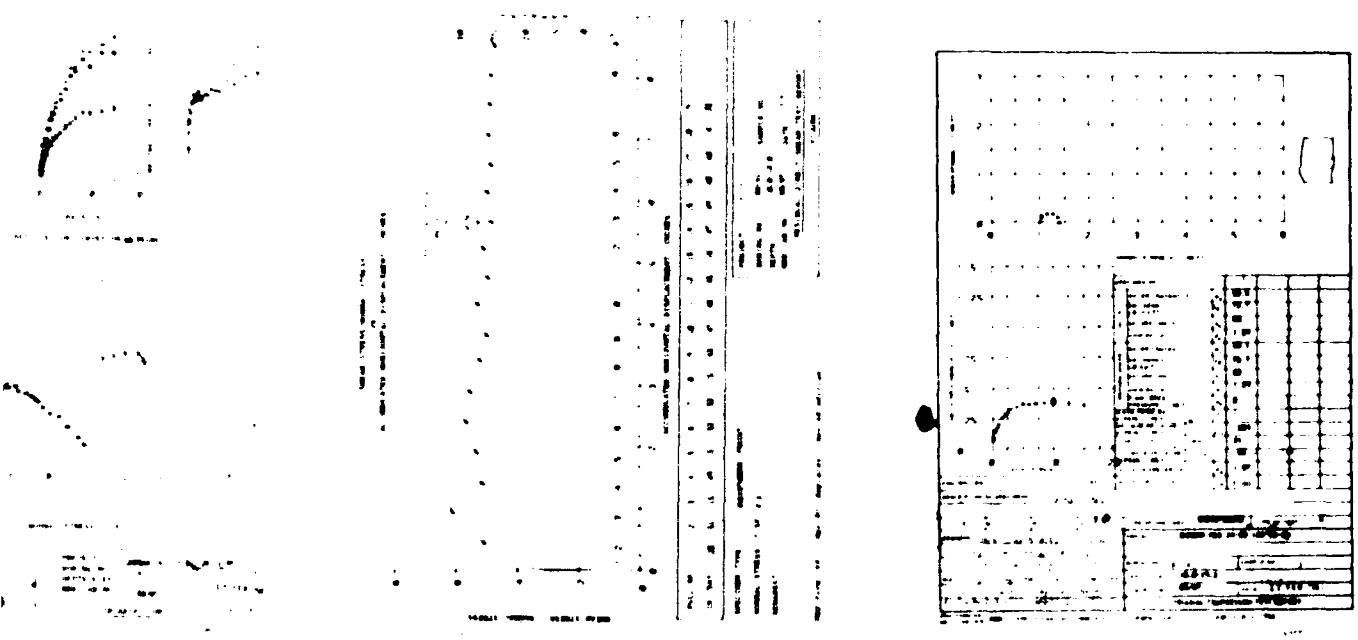
M34-CH-9-5/83

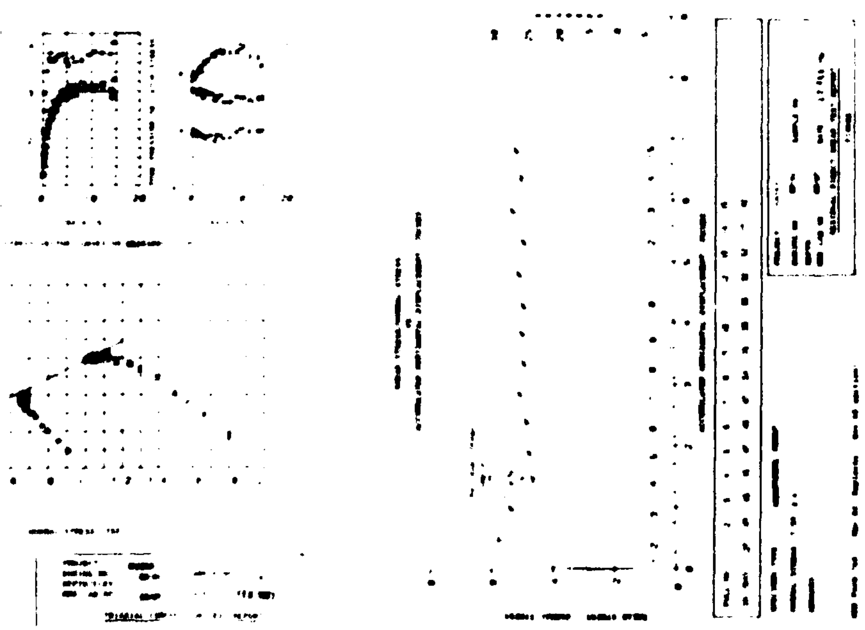
PLATE C-16











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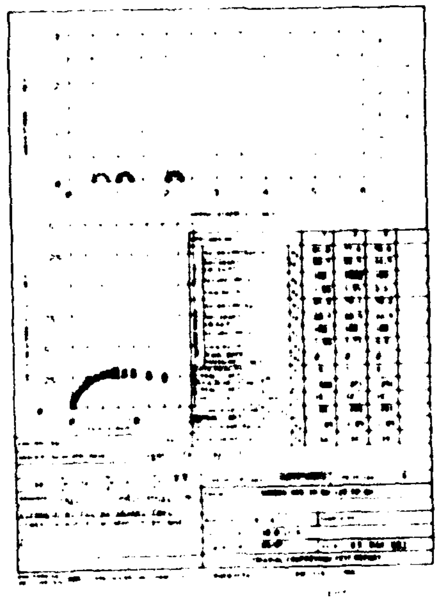
FLOOD CONTROL MINNESOTA RIVER
CHASKA, MINNESOTA

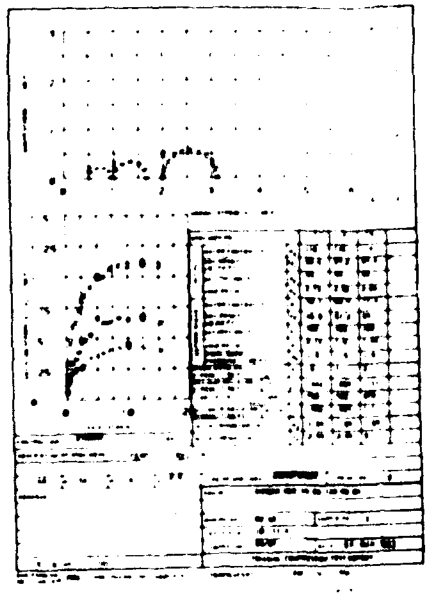
TRIAXIAL TESTS

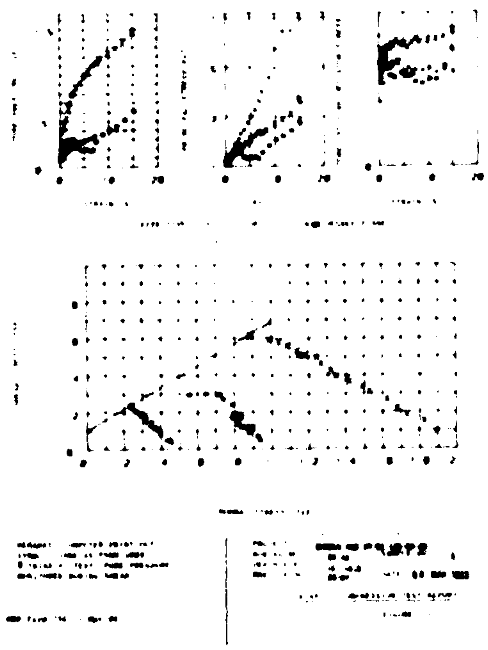
MARCH 1984

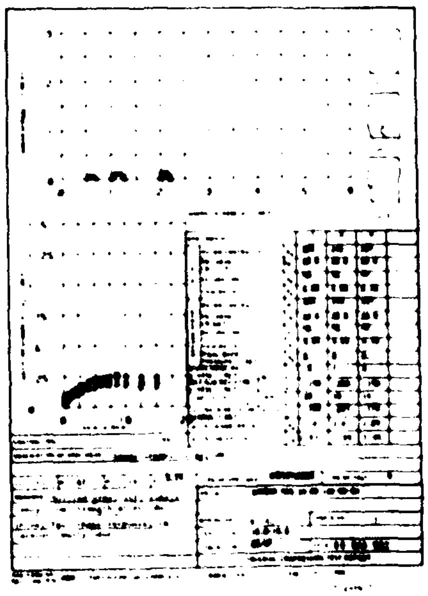
M34-CH-9-3/84

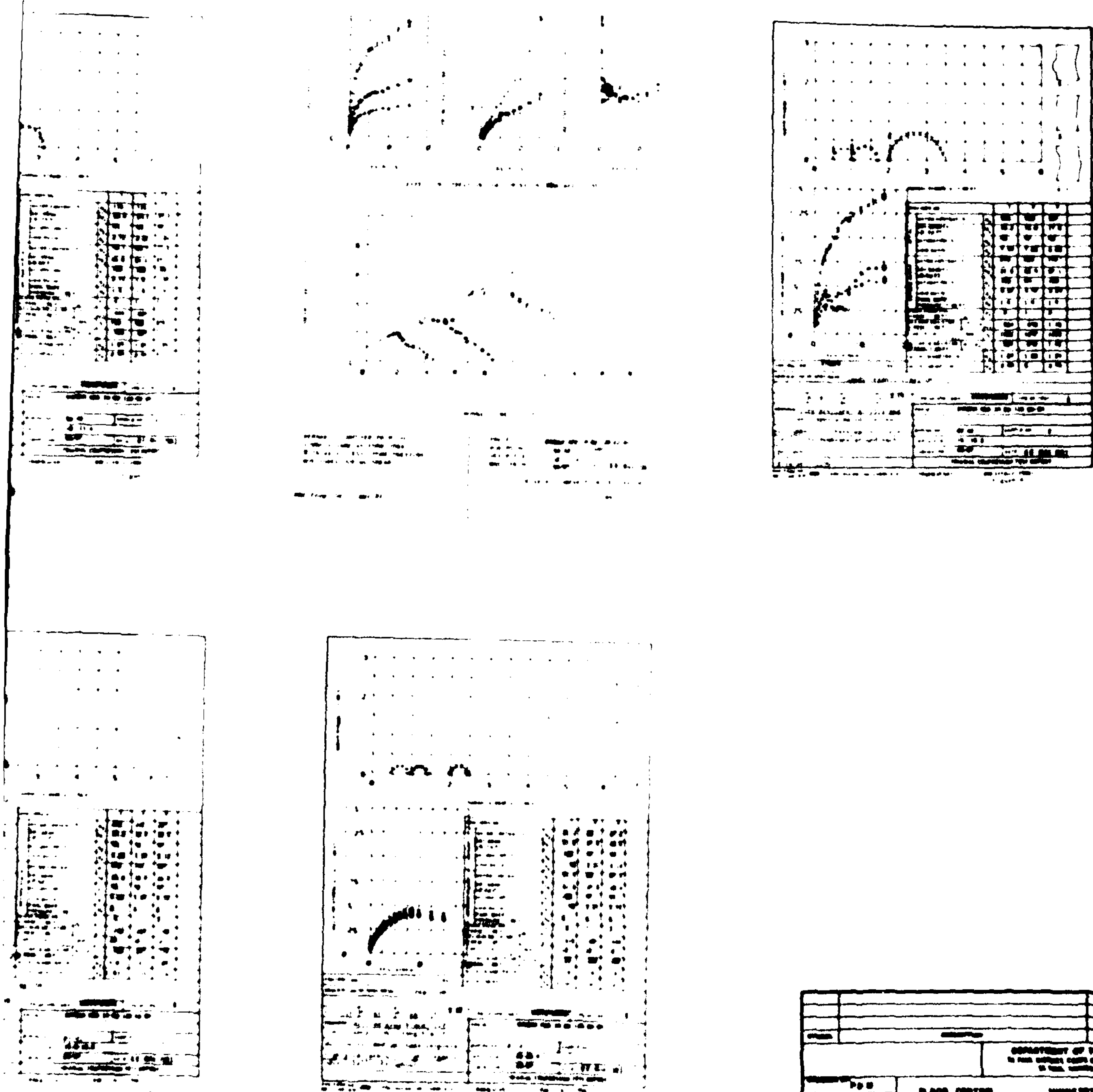
PLATE C-17







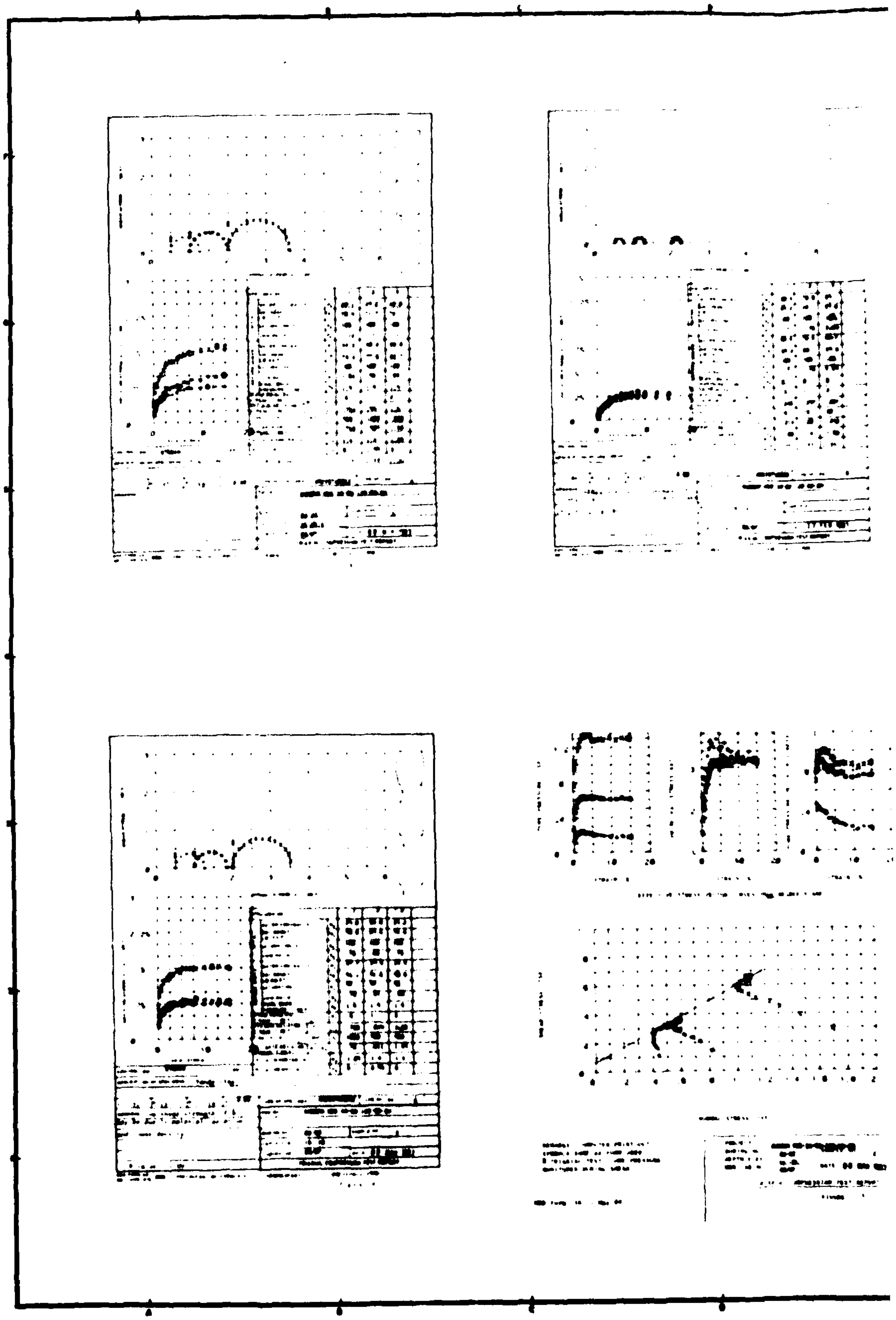


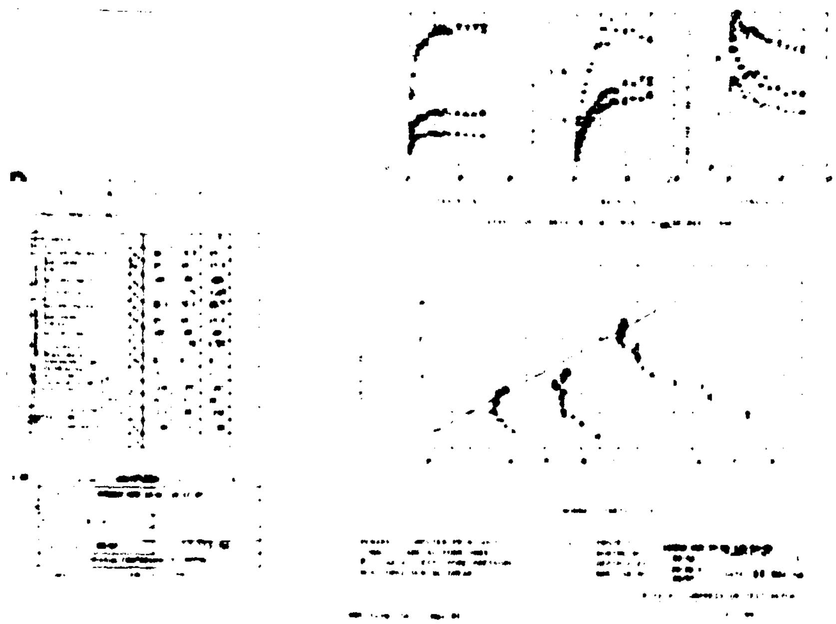


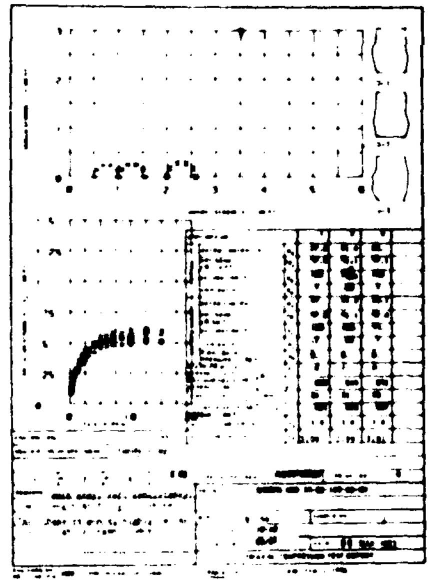
FLOOD CONTROL MINNESOTA RIVER
CHASKA, MINNESOTA
TRIAXIAL TESTS

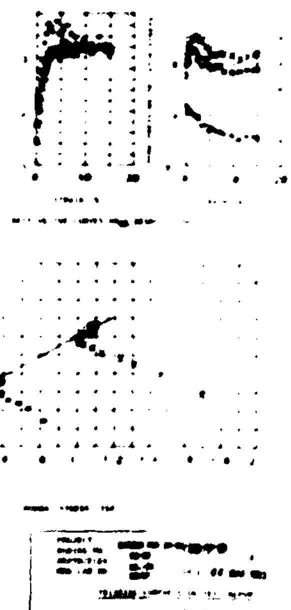
M34-CH-9-5/86

PLATE C-10









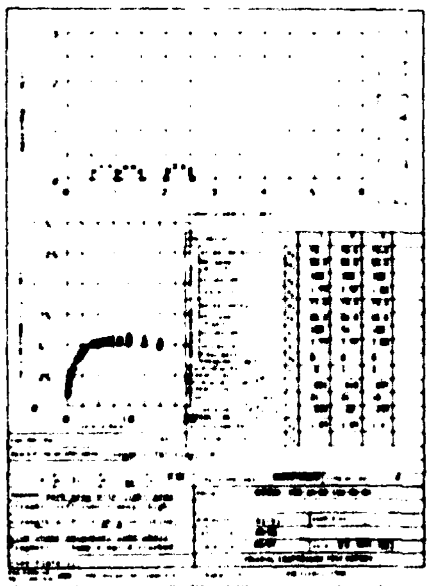


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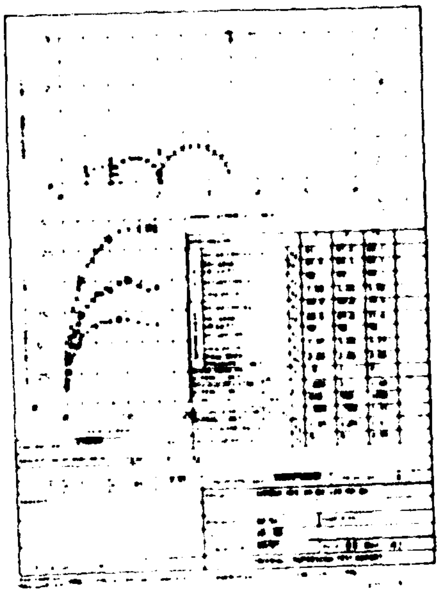
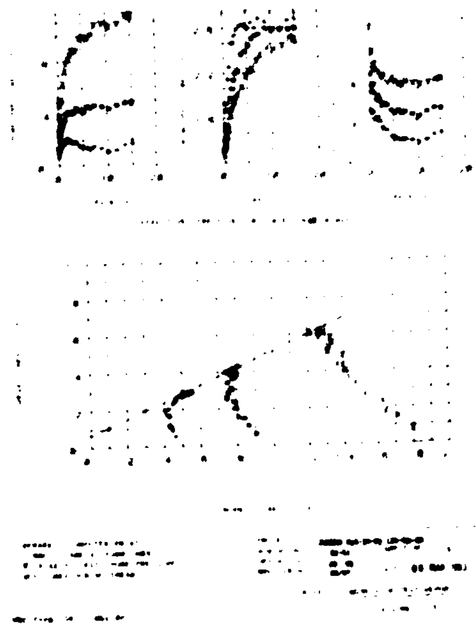
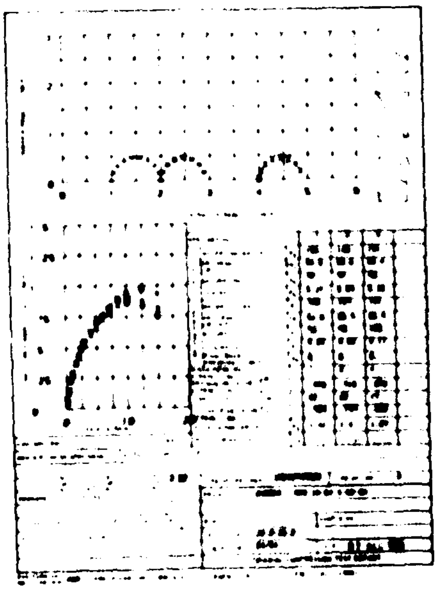
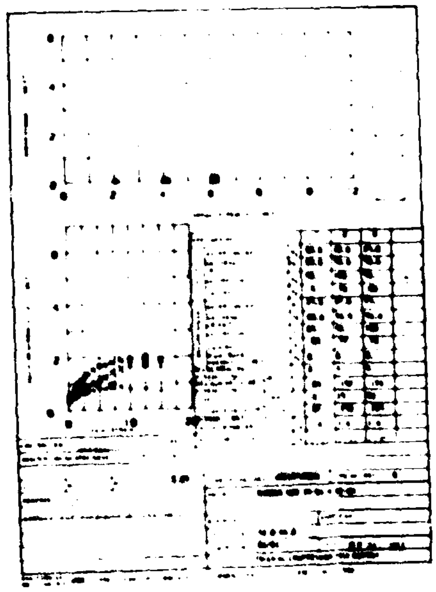
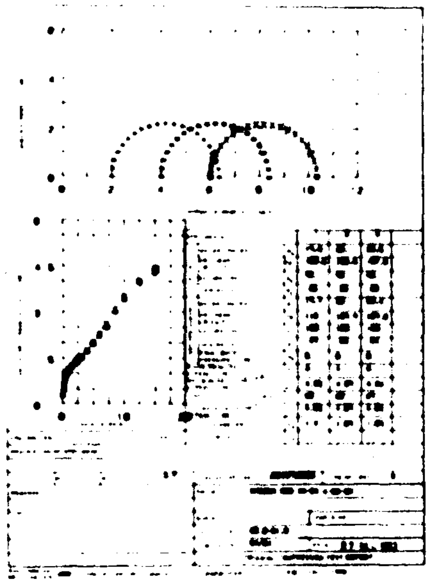
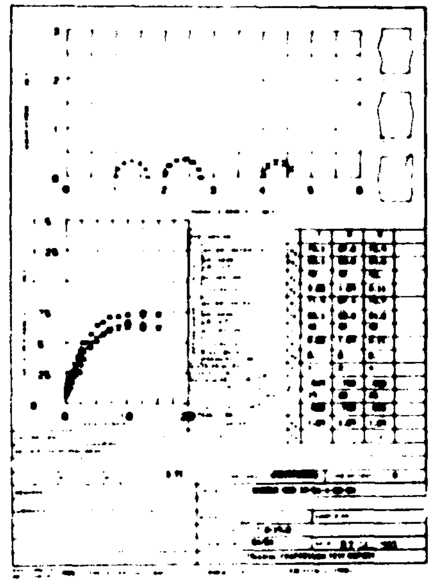
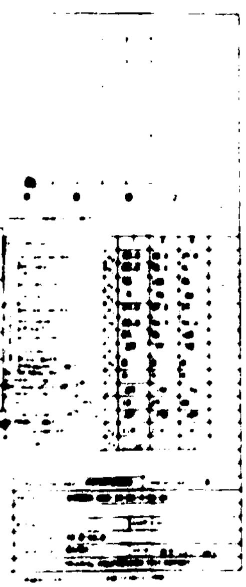
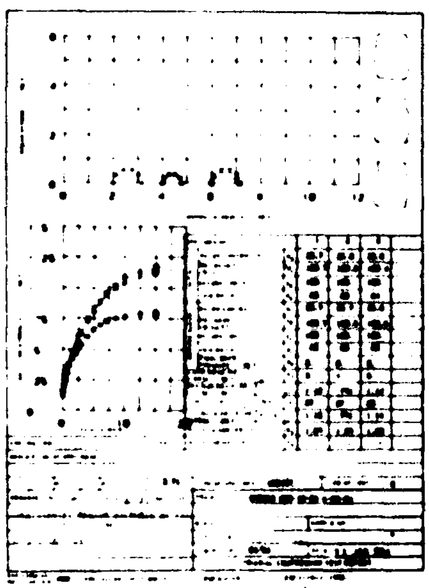
PLATE C-19









FLOOD CONTROL

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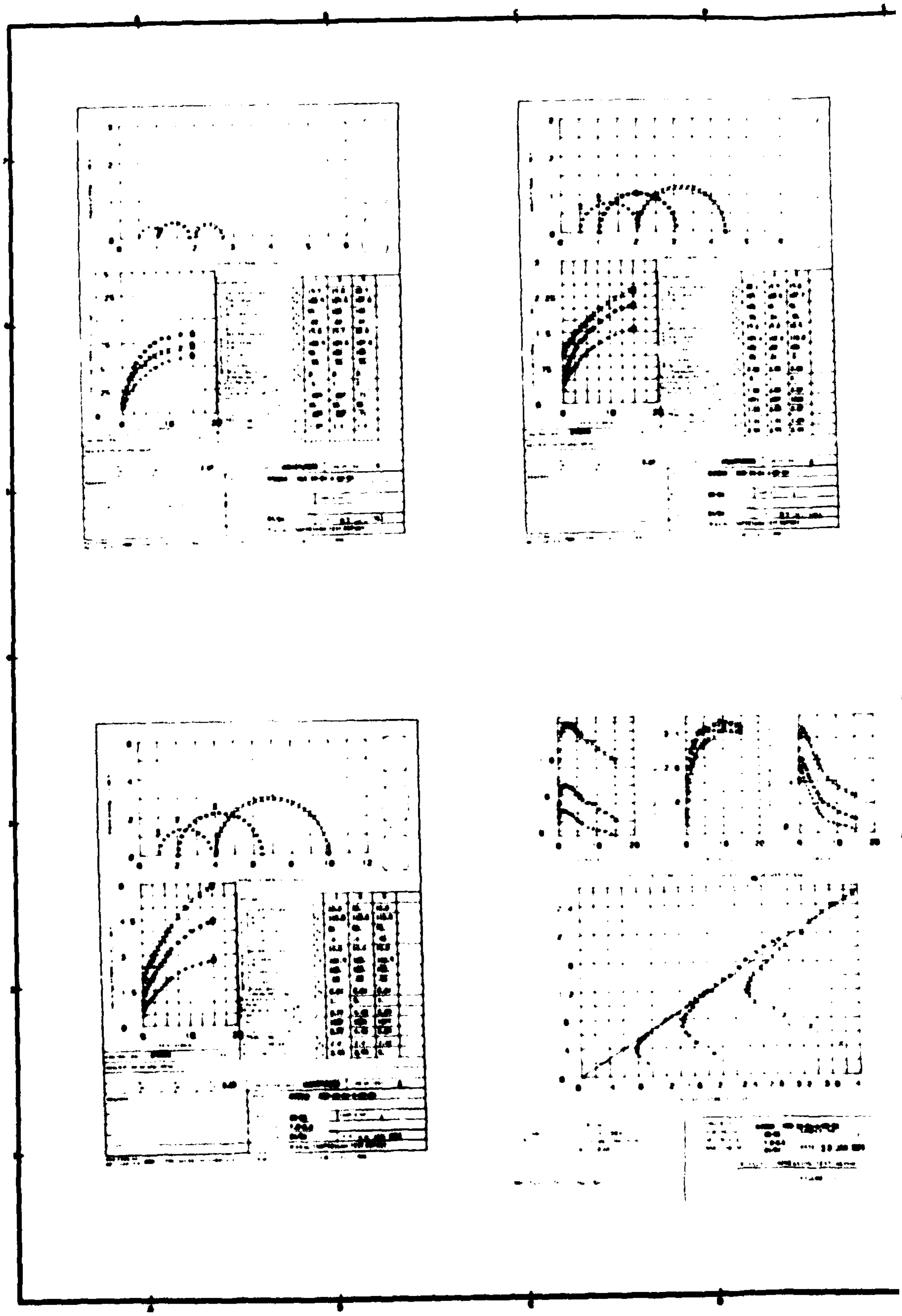
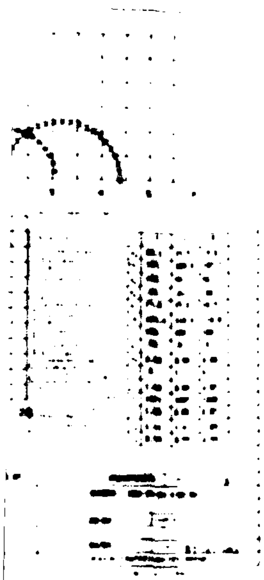
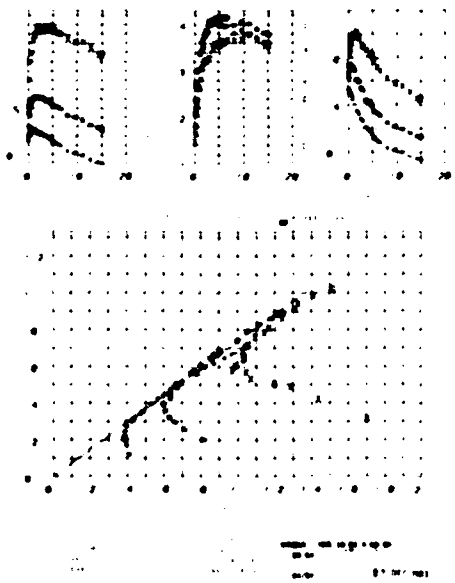
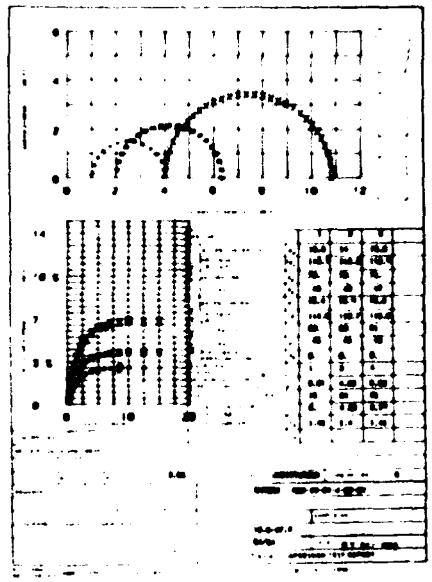
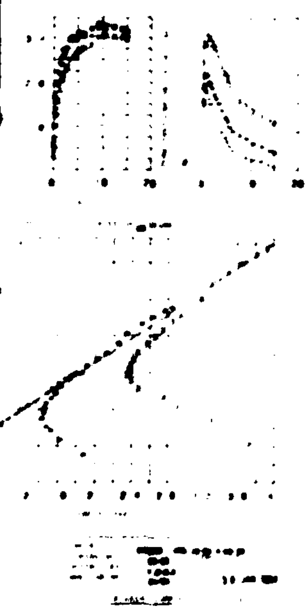
PLATE C-20











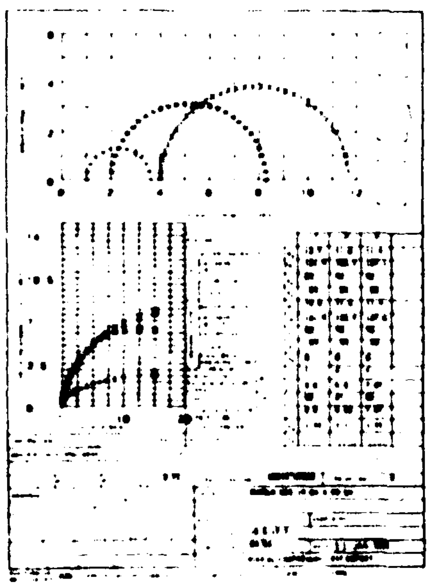


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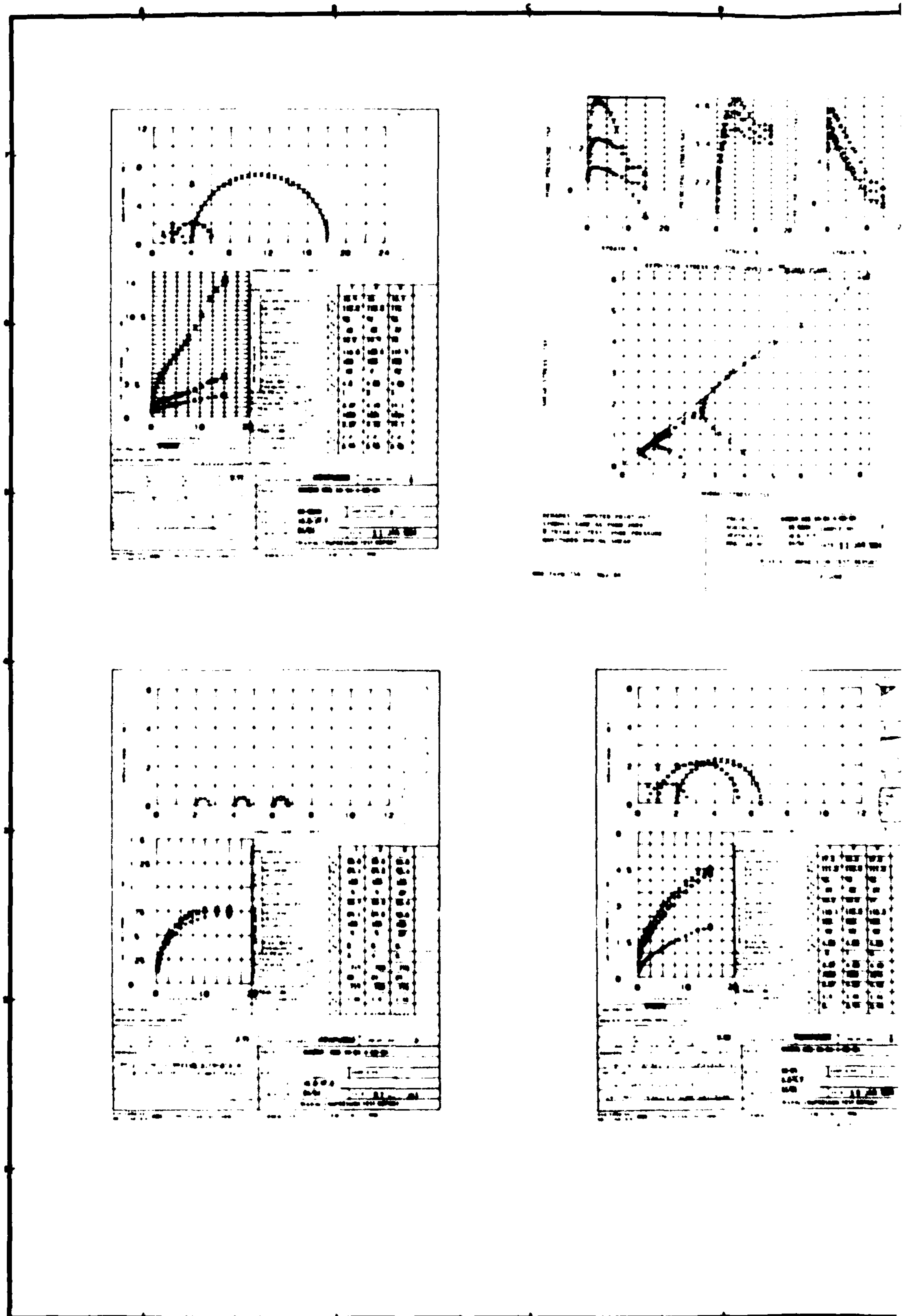
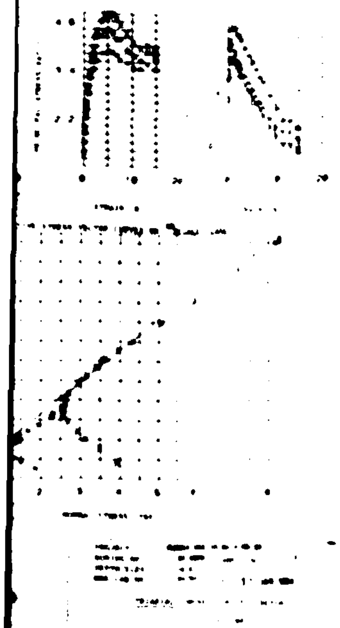
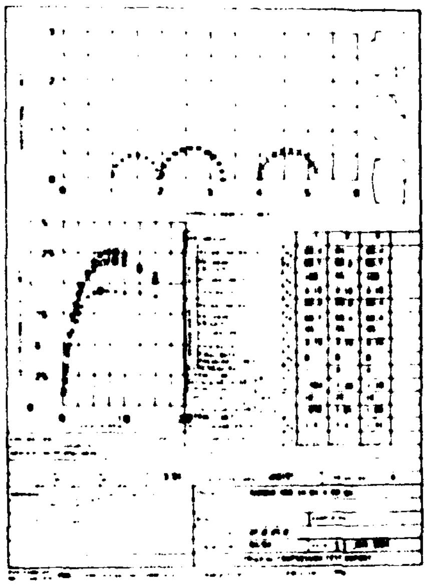
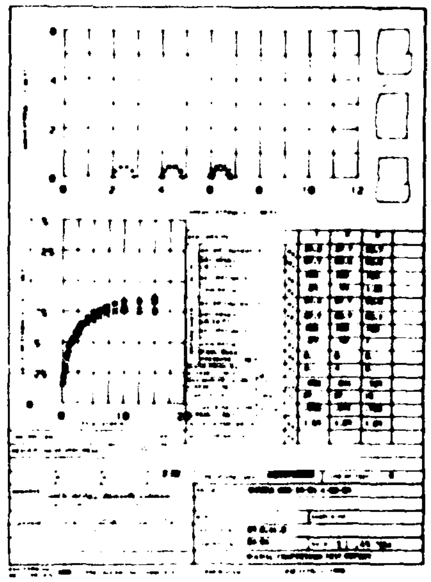
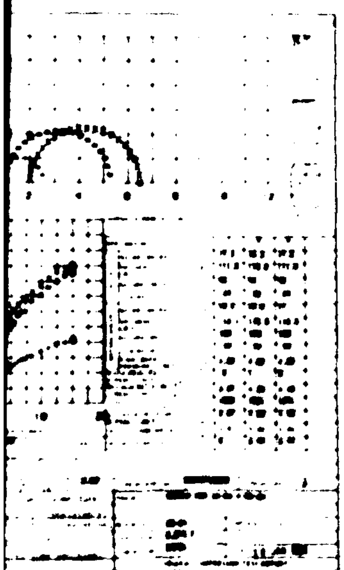
PLATE C-31

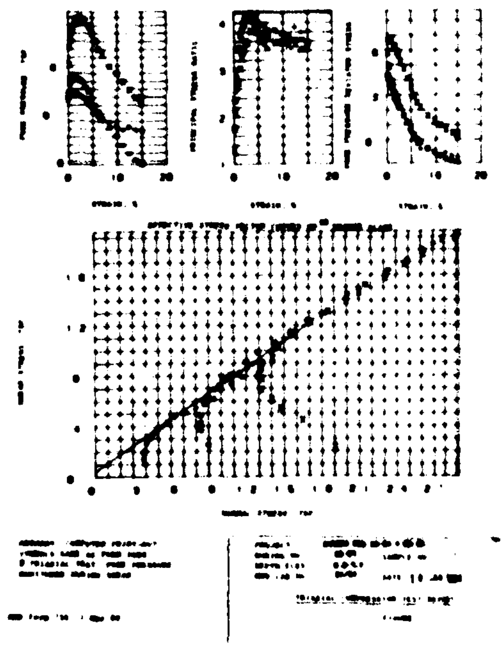












FLOOD CONTROL MINNESOTA RIVER
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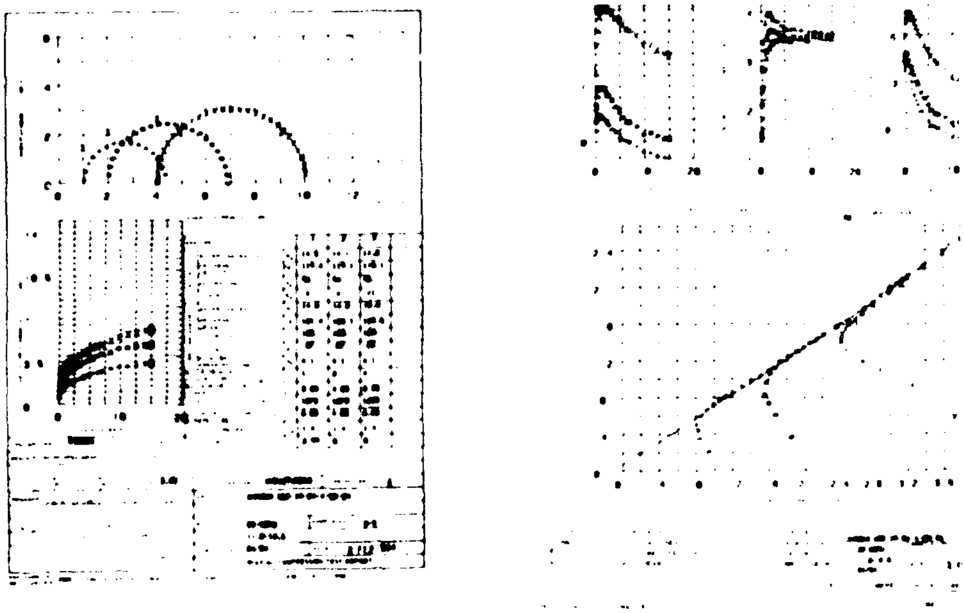
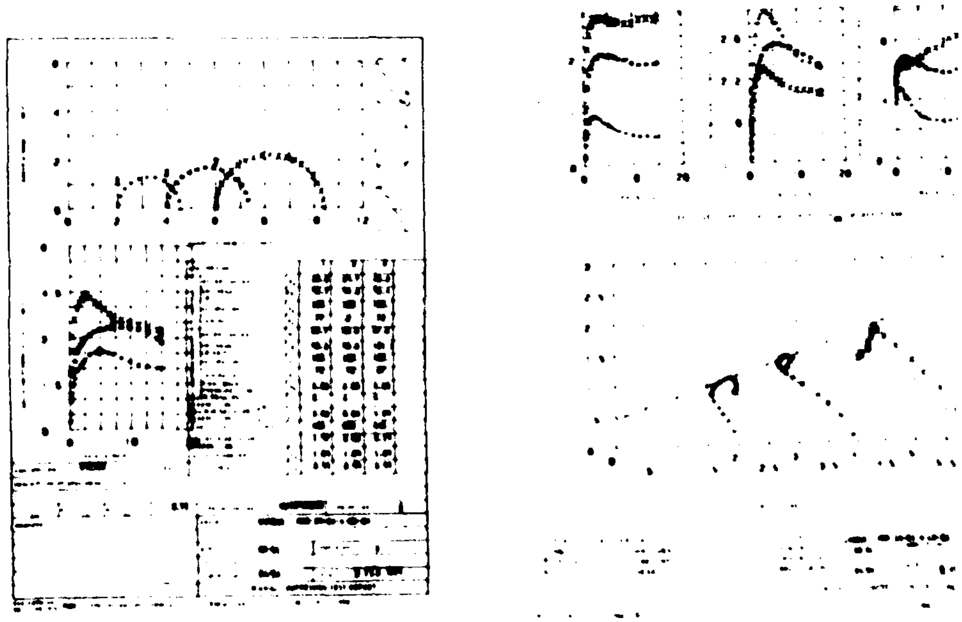
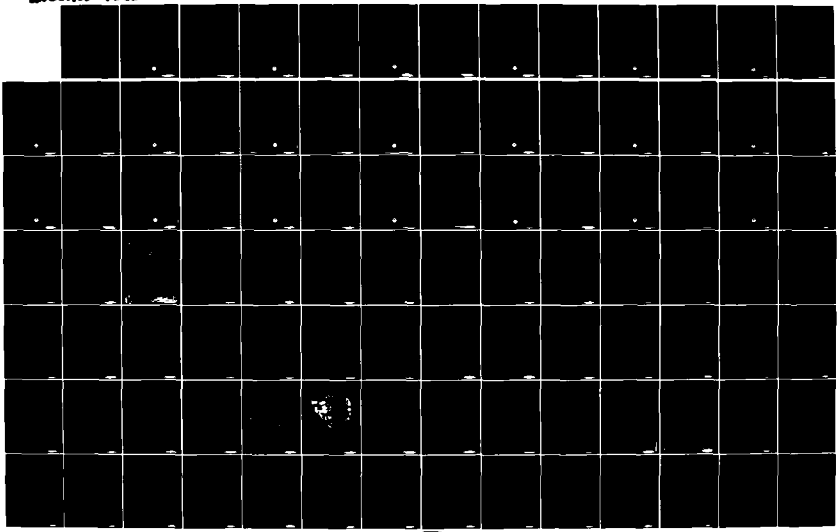
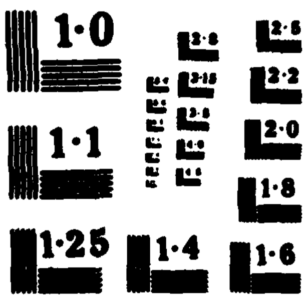




AD-A146 795 MINNESOTA RIVER AT CHASKA MINNESOTA FLOOD CONTROL PROJECT GENERAL DESIGN..(U) CORPS OF ENGINEERS ST PAUL MN ST PAUL DISTRICT AUG 84 5/6

UNCLASSIFIED F/G 13/2 NL

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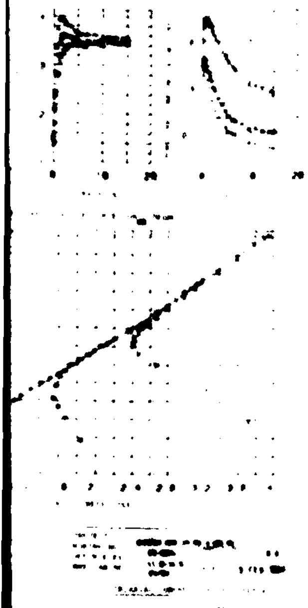

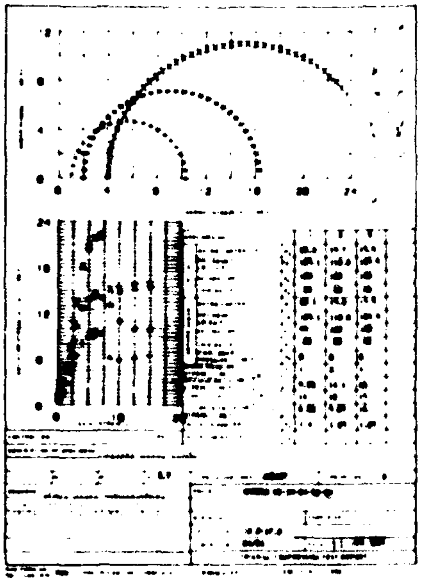

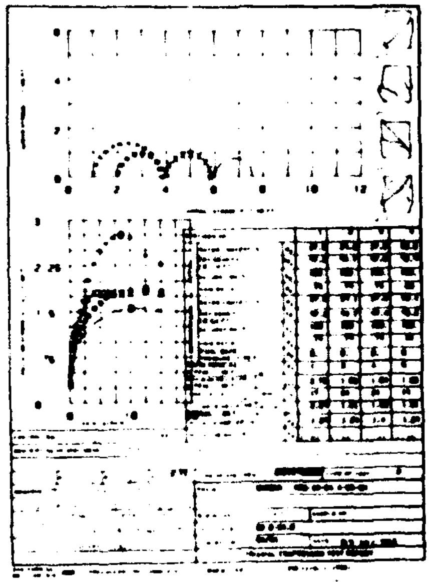

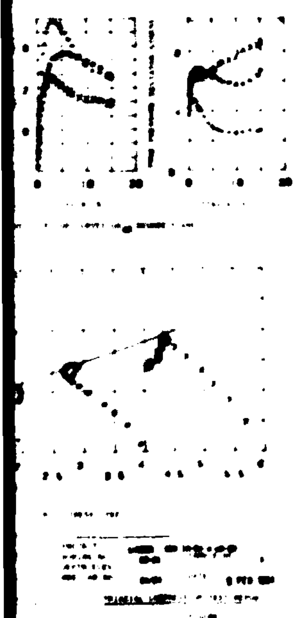

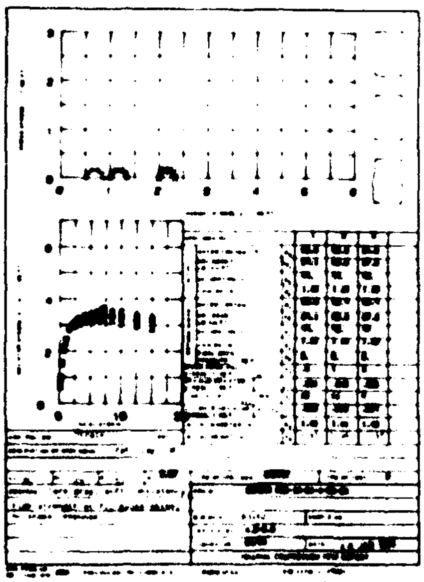

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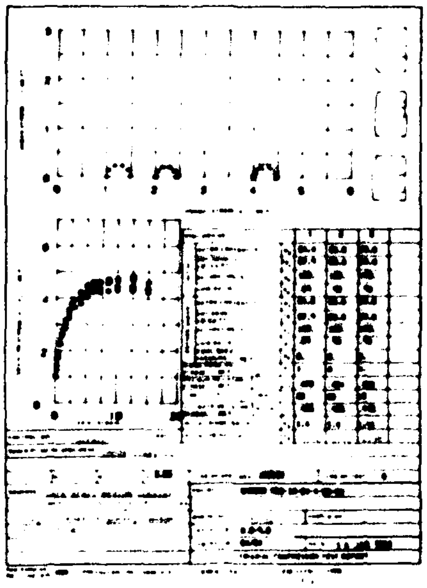
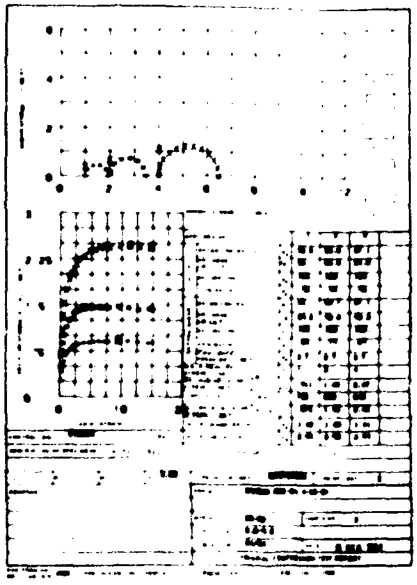
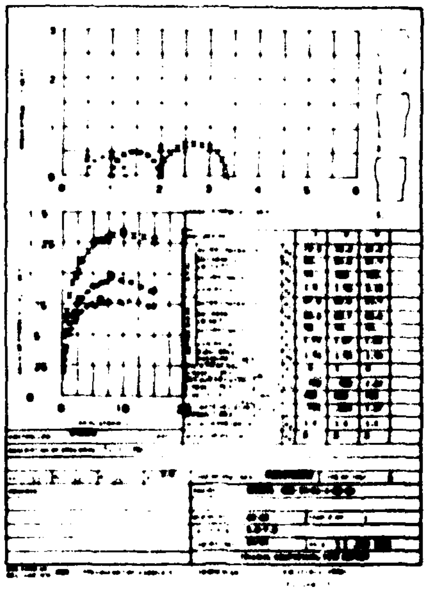
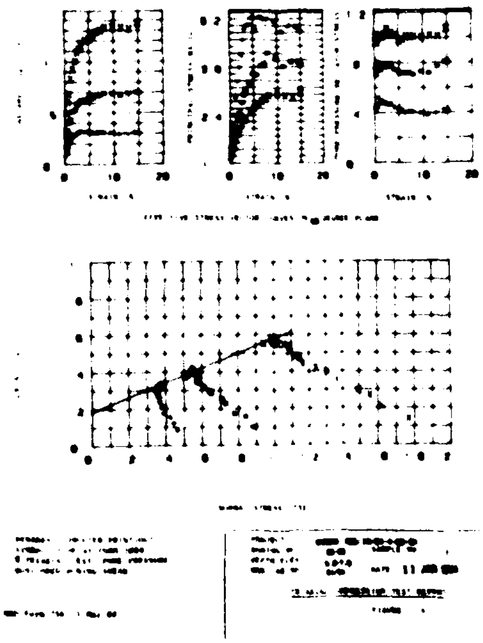
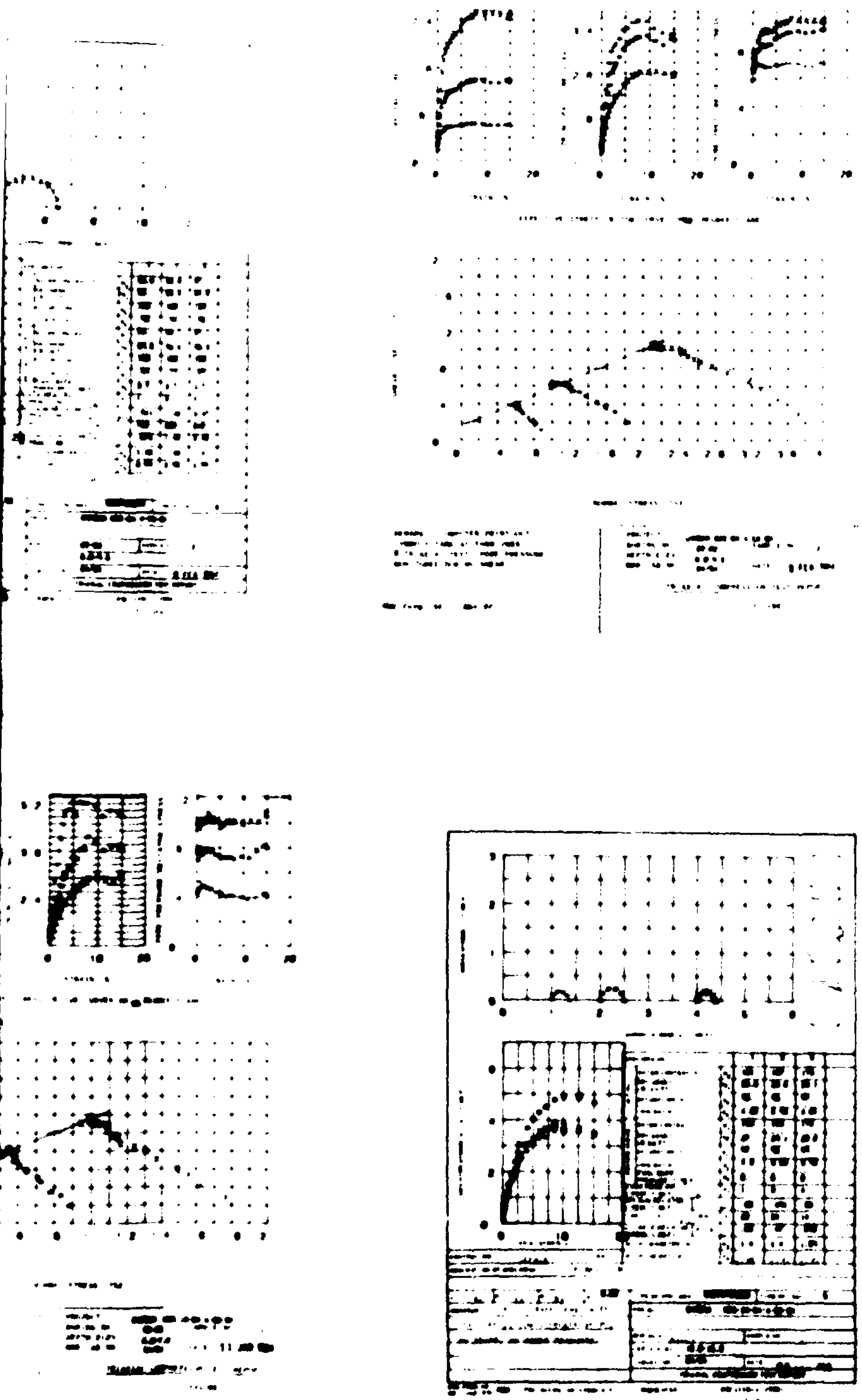
PLATE C-8[illegible]











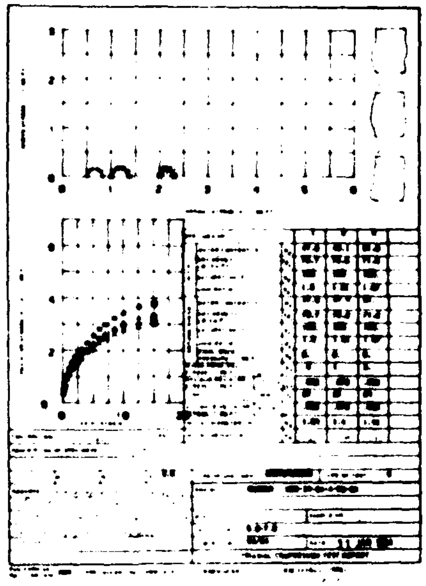


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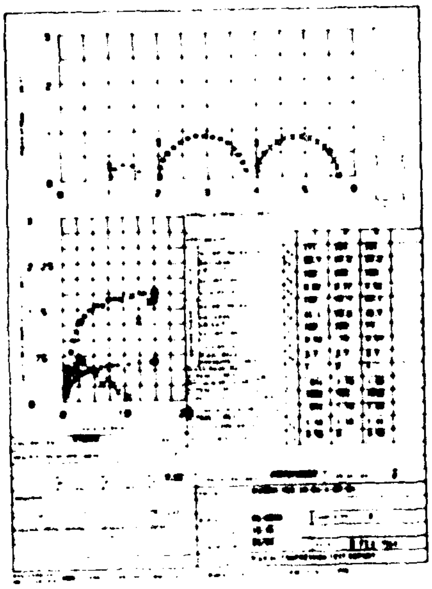
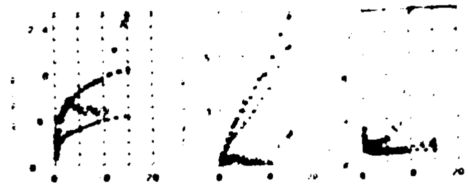
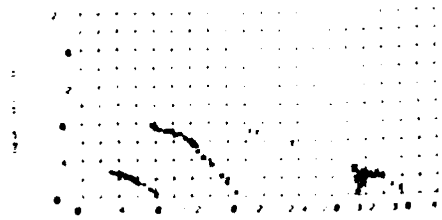
PLATE C-24







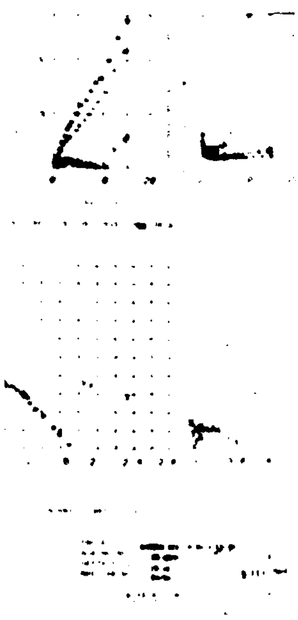


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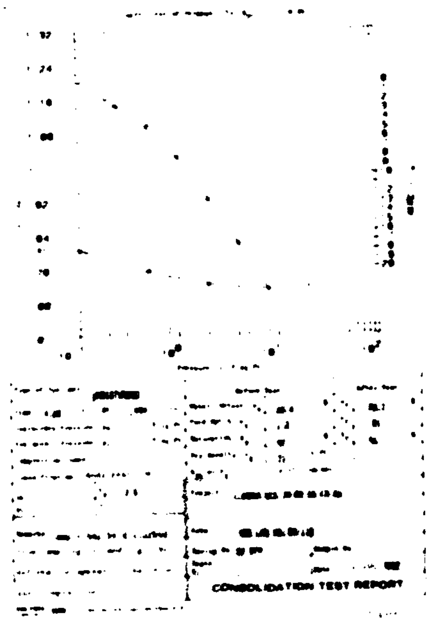
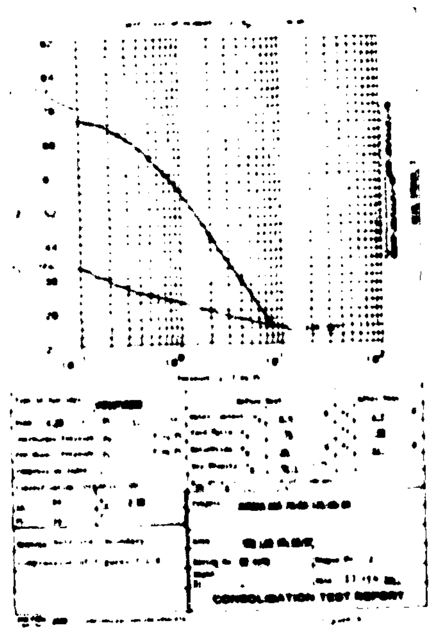
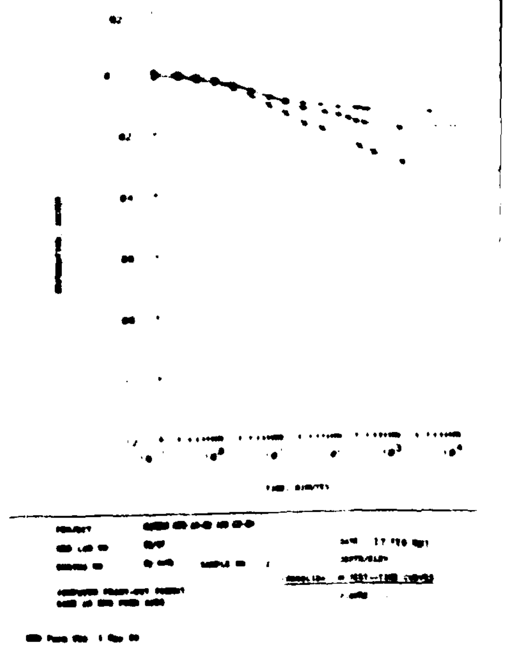
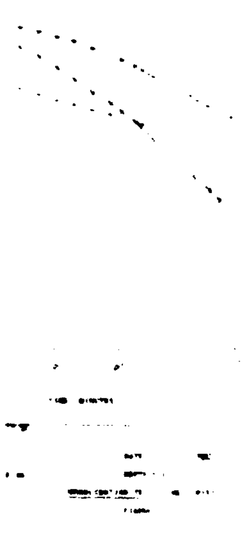
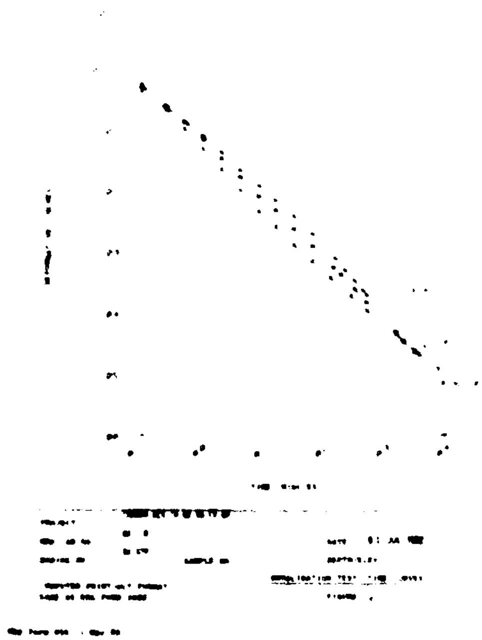
PLATE C-2[illegible]

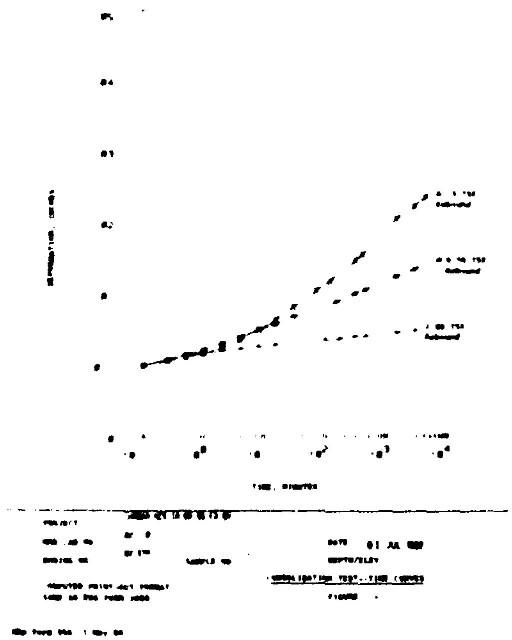

CONSOLIDATION TEST REPORT

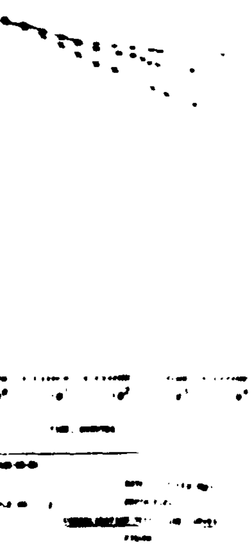

CONSOLIDATION TEST REPORT











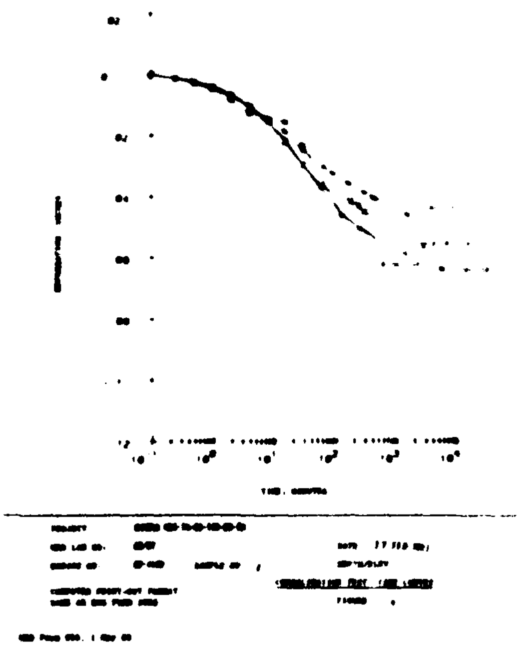


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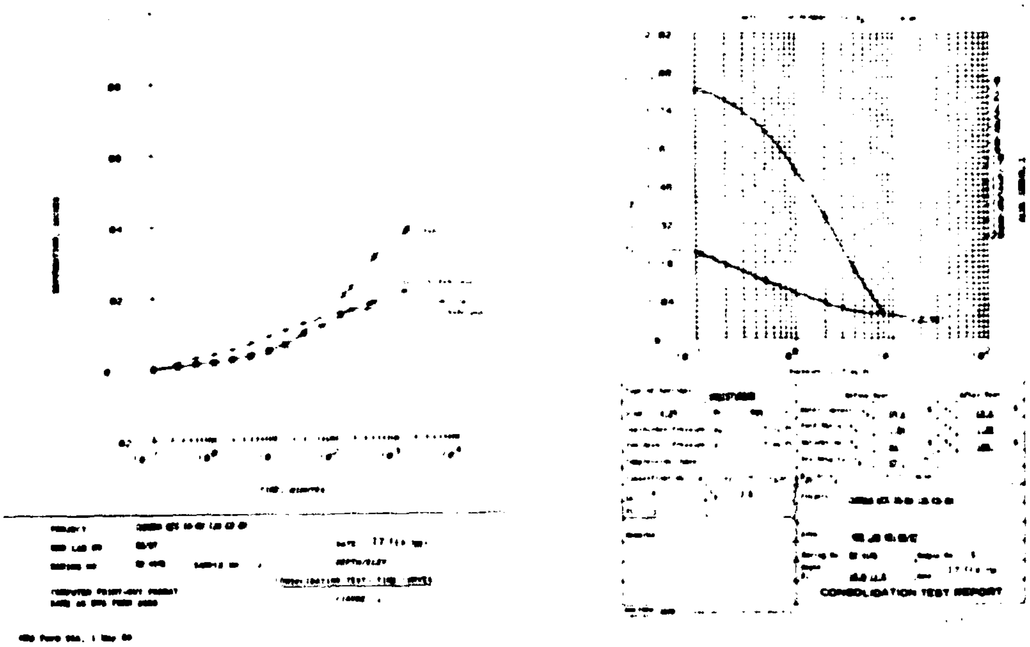
PLATE C-[illegible]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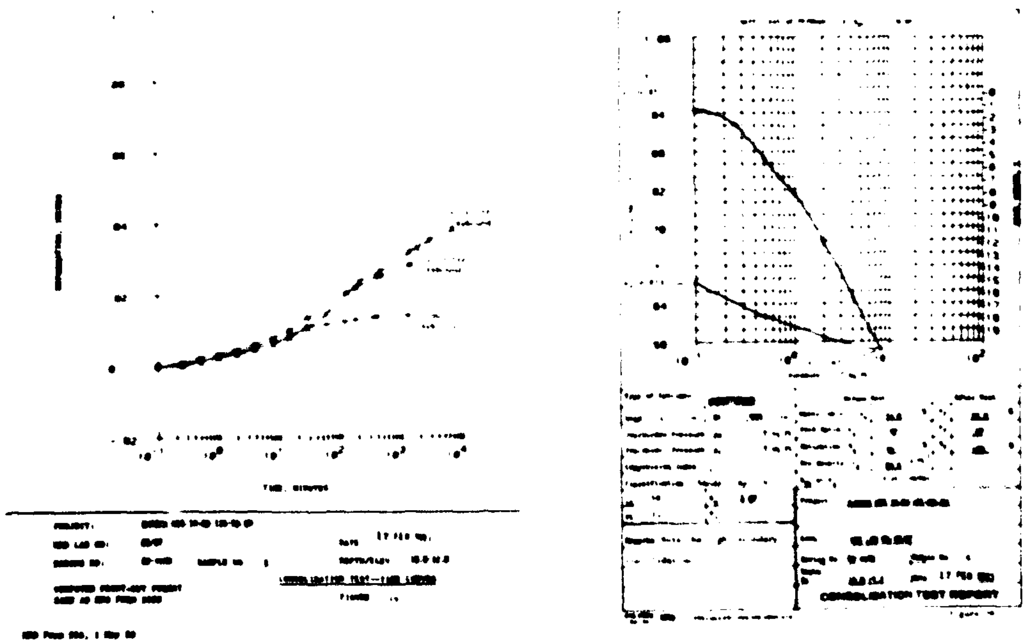
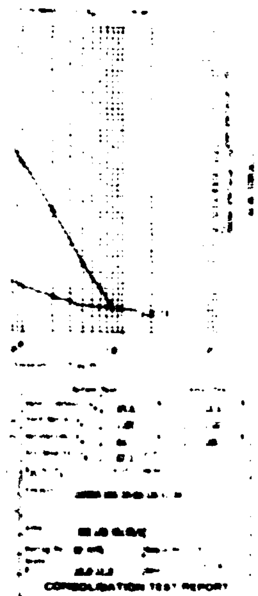
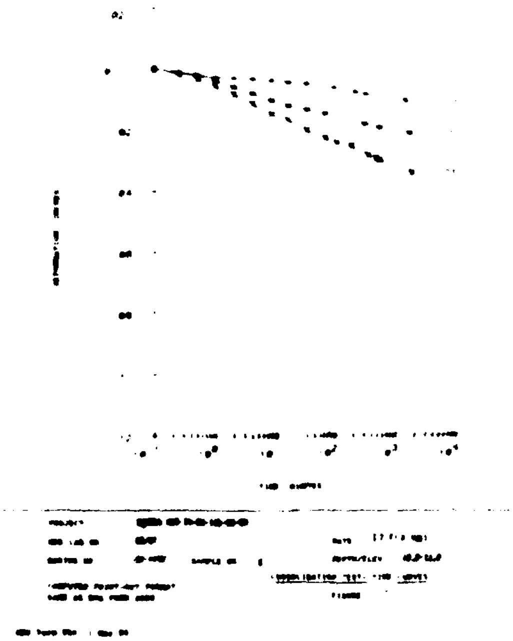
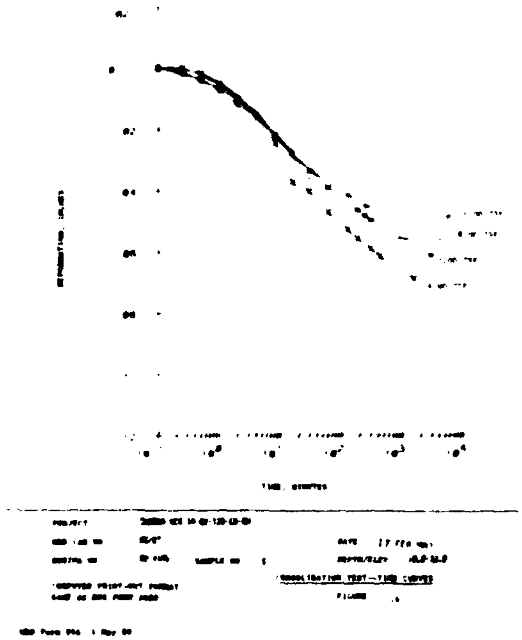
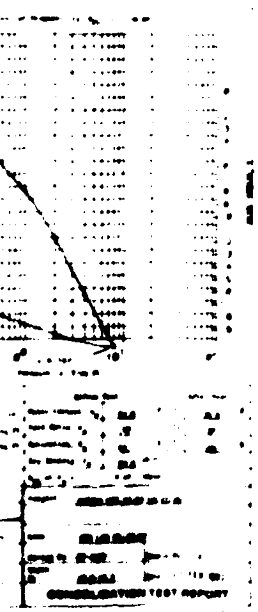

CONSOLIDATION TEST REPORT









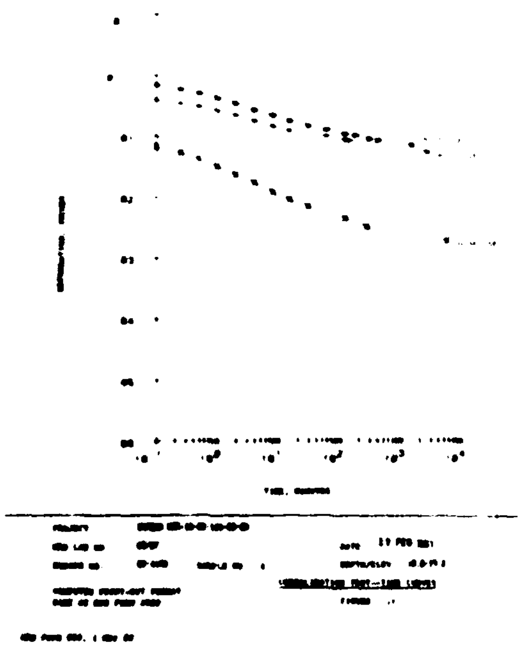


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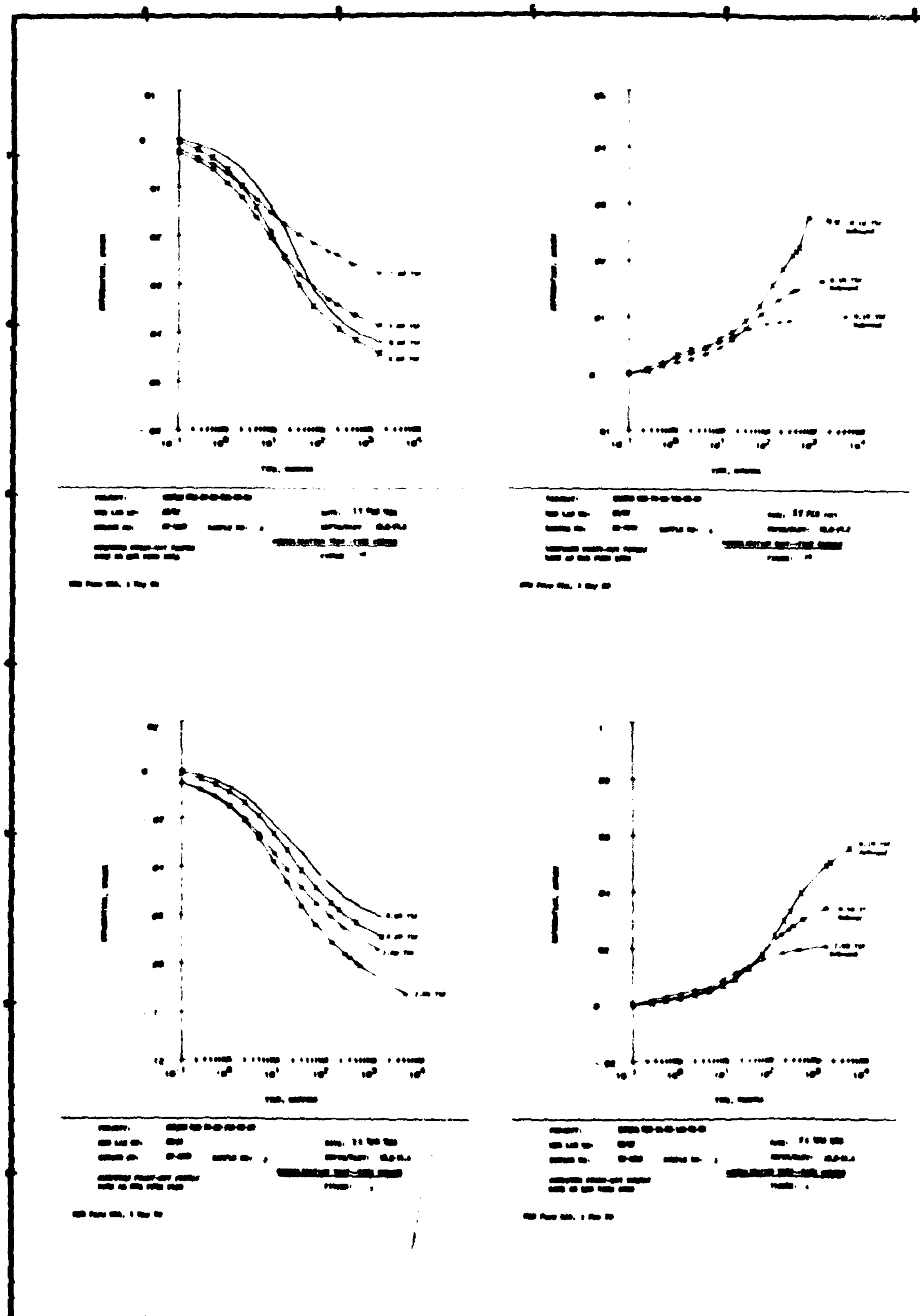
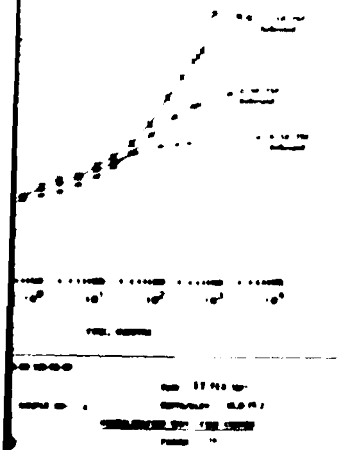
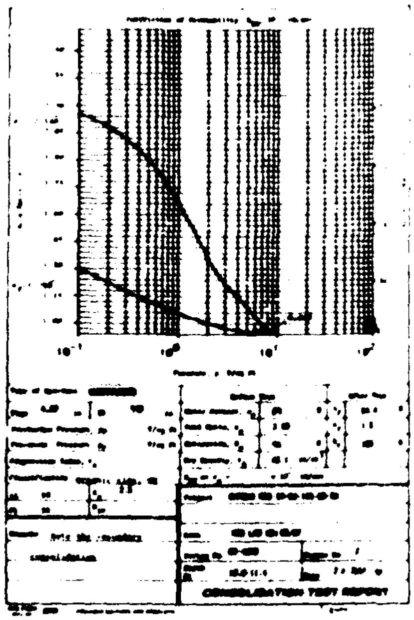
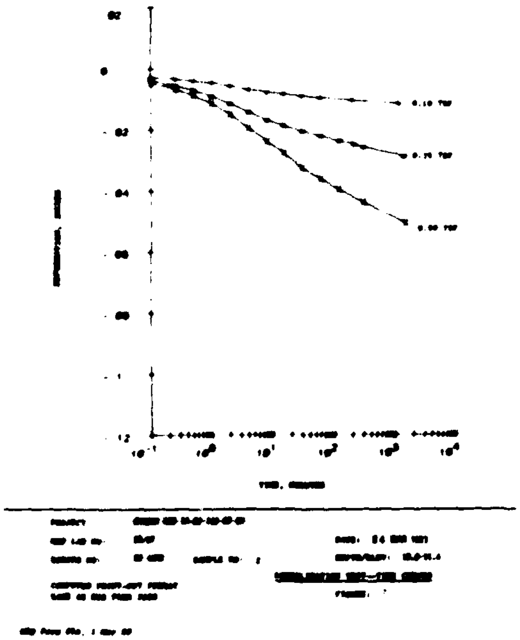
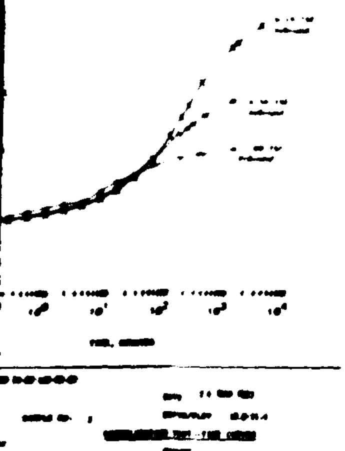
PLATE C-27

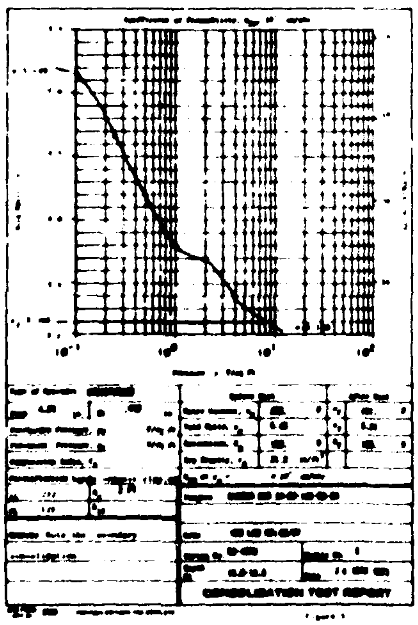












FLOOD CONTROL MINNESOTA RIVER
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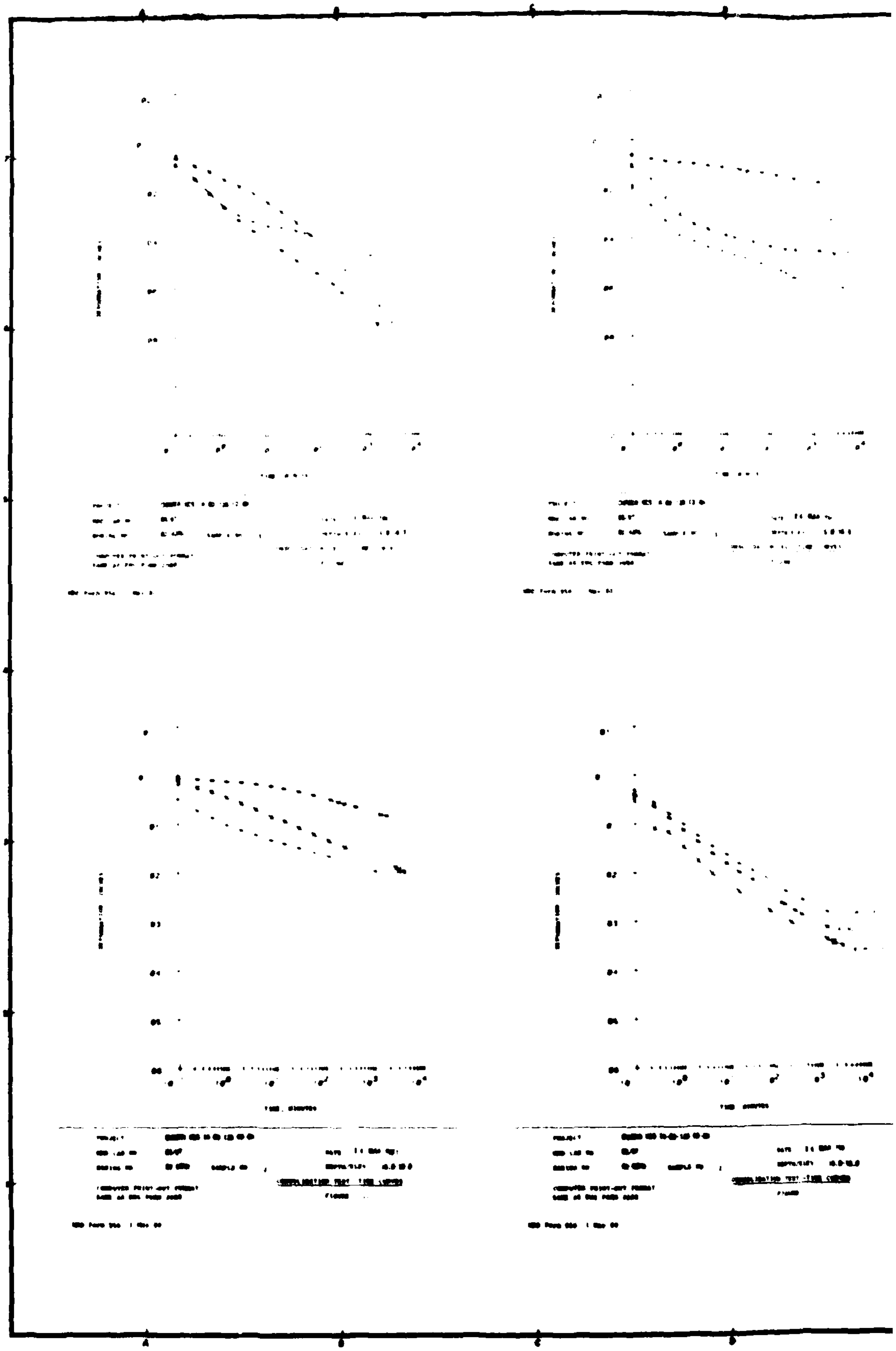
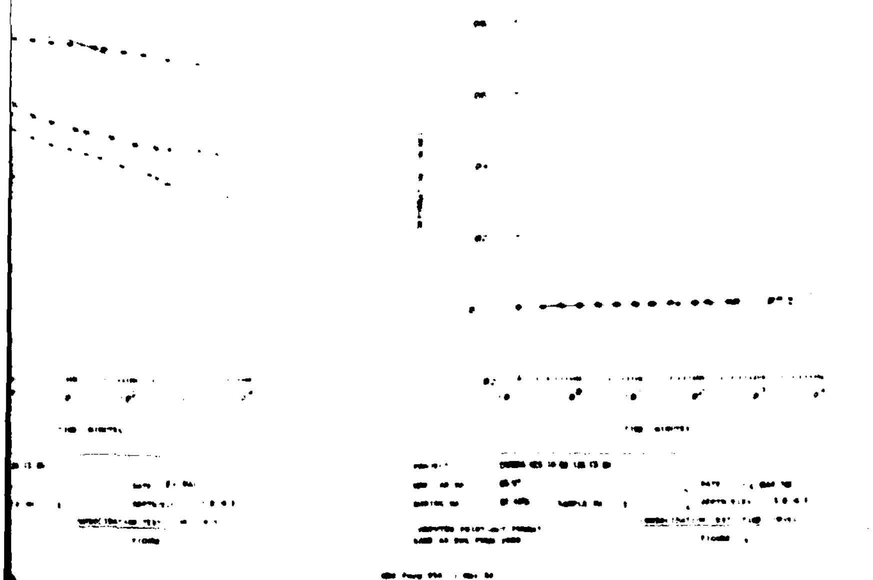
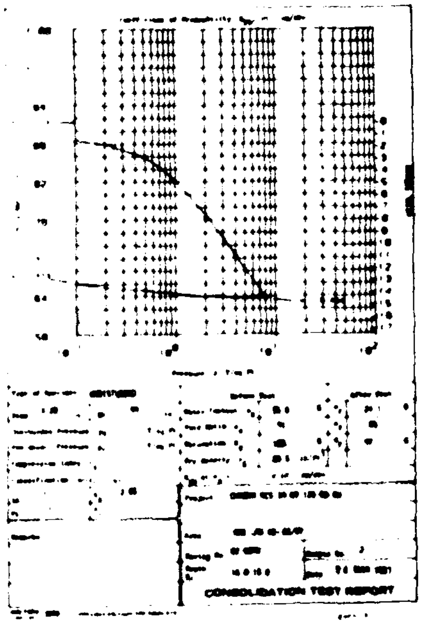
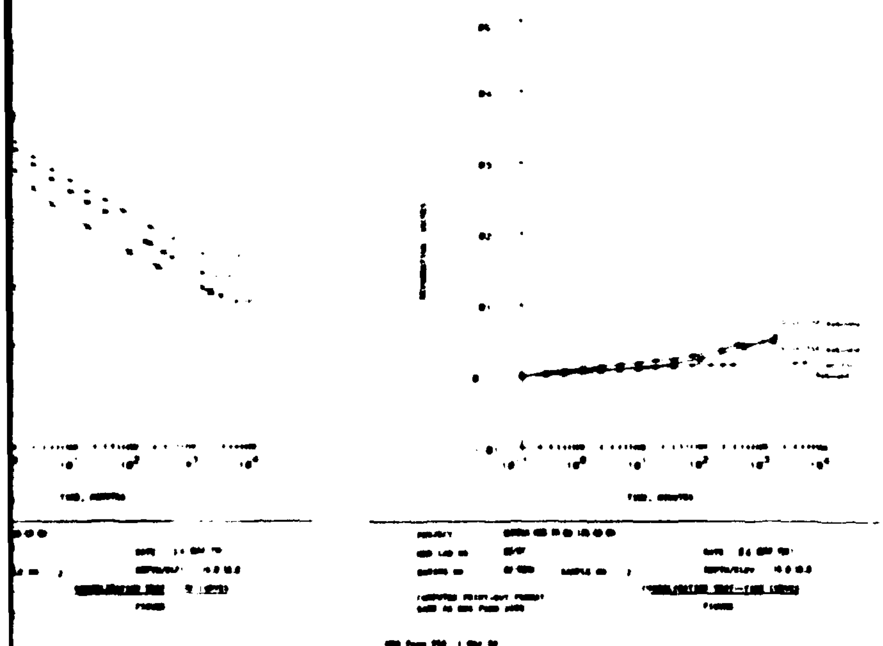
PLATE C-26









FLOOD CONTROL MINNESOTA RIVER

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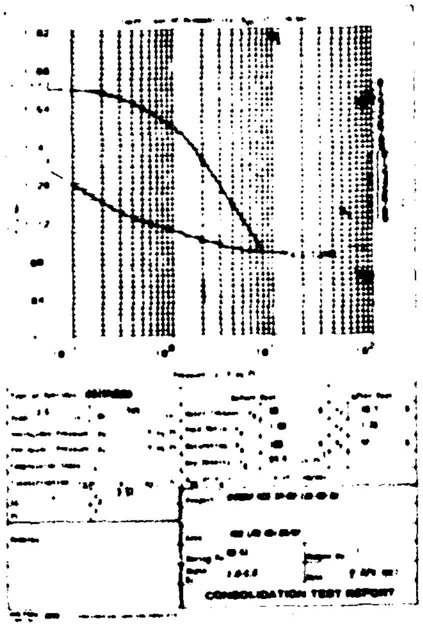
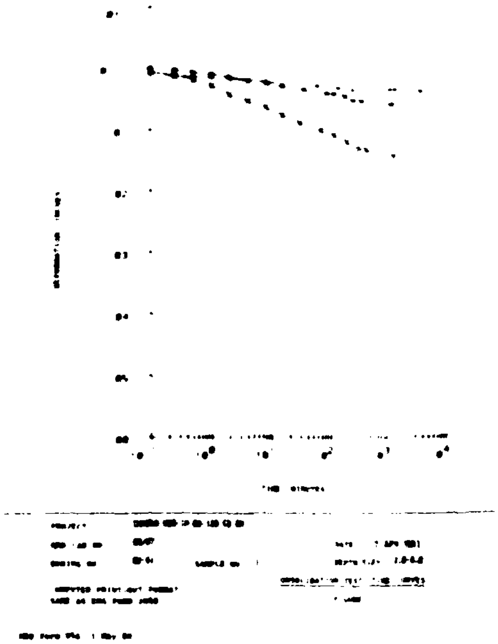
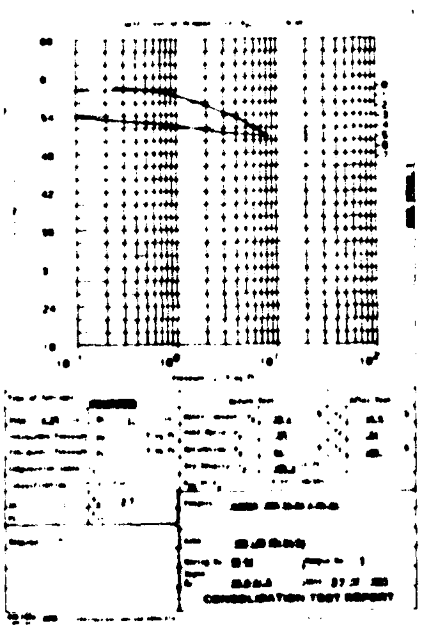
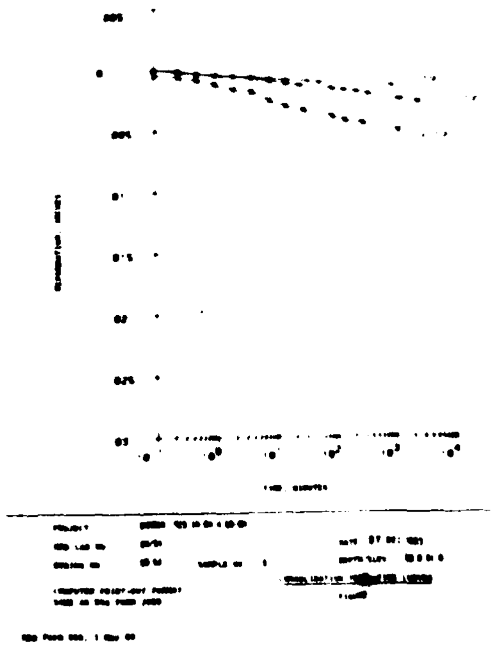
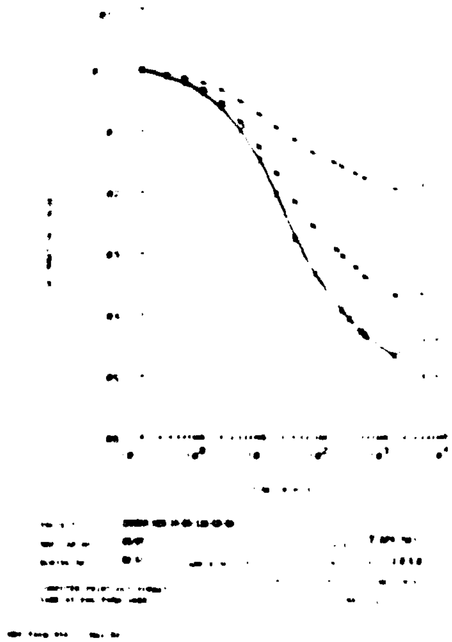
PLATE C-29

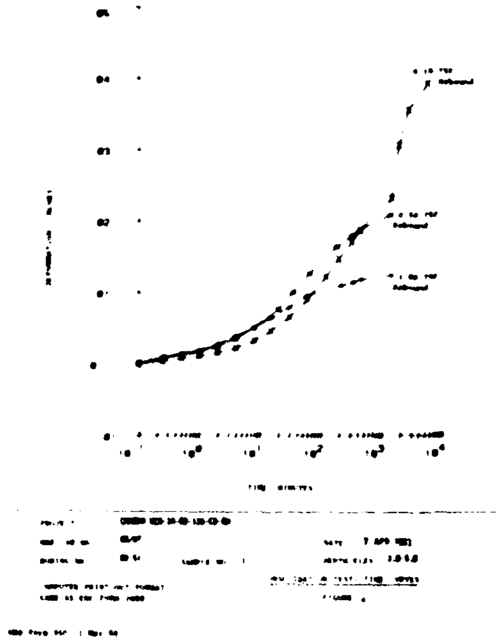

CONSOLIDATION TEST REPORT

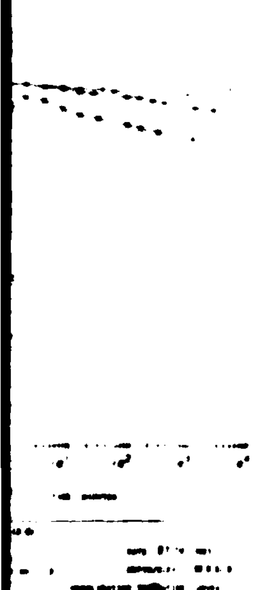



CONSOLIDATION TEST REPORT









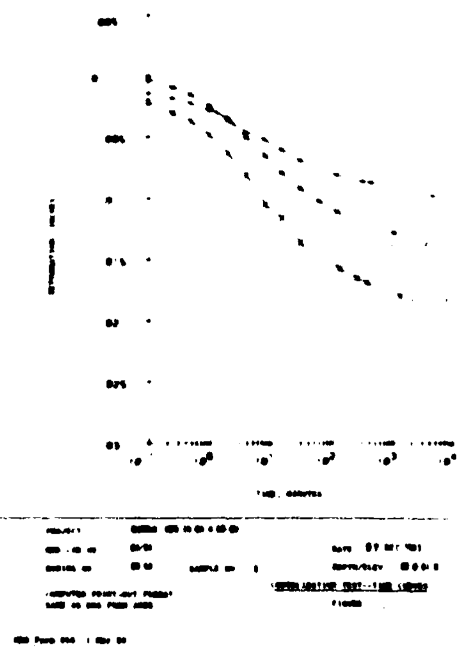


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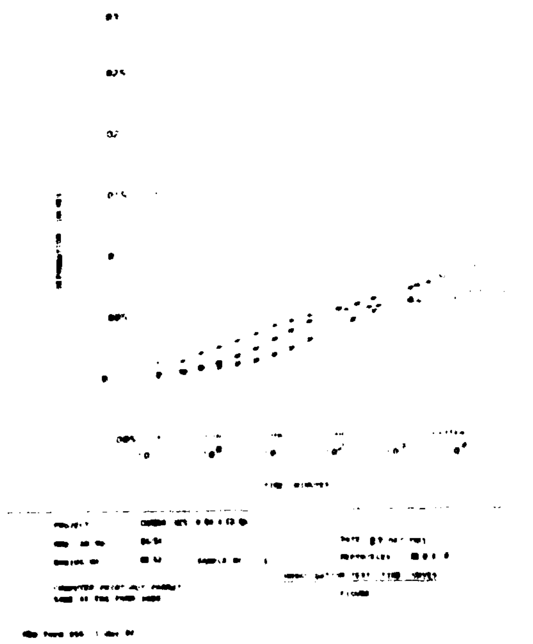
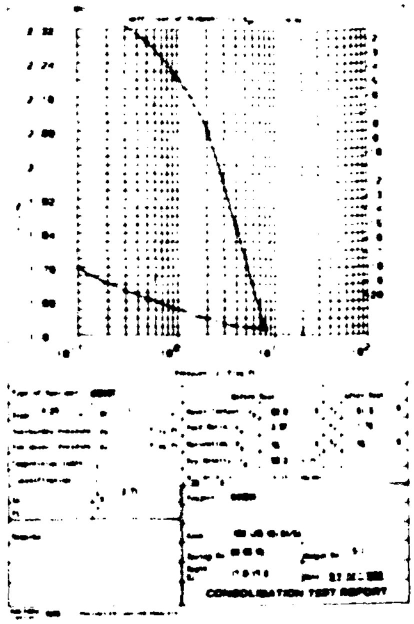
PLATE C-30

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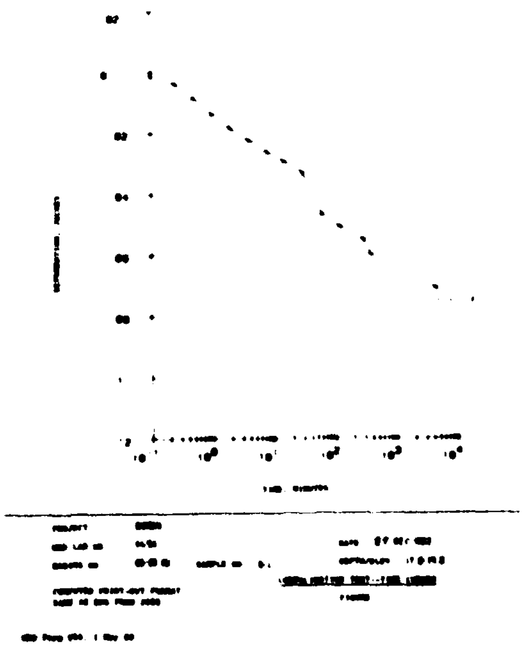

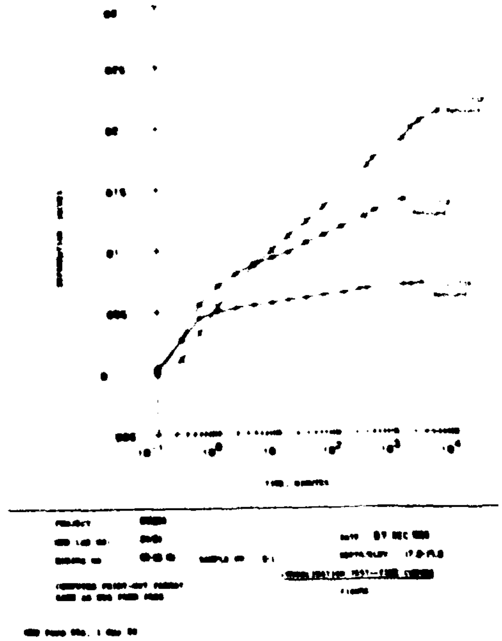

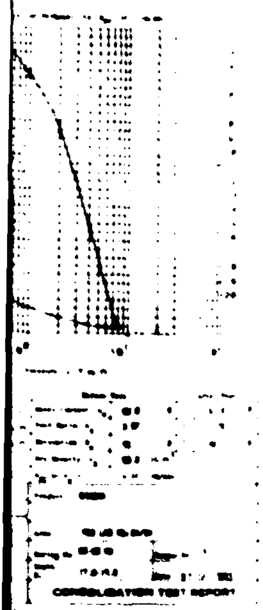

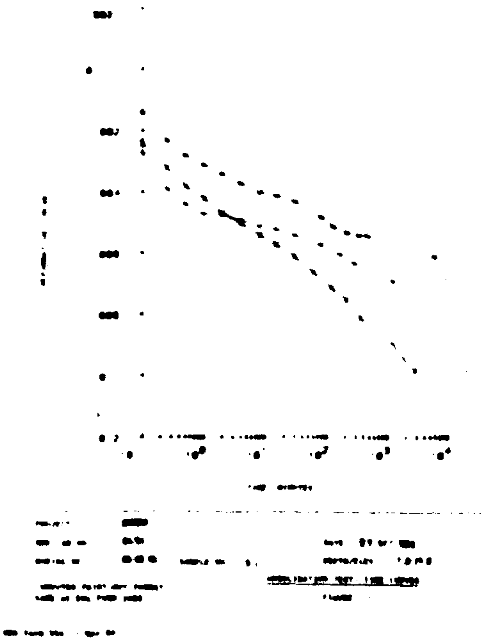

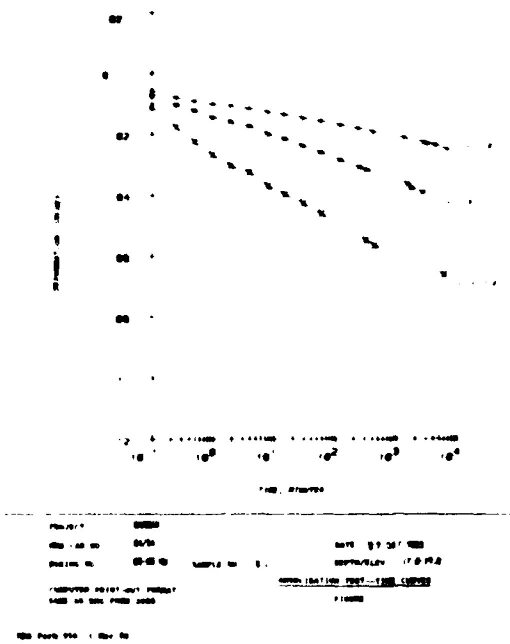

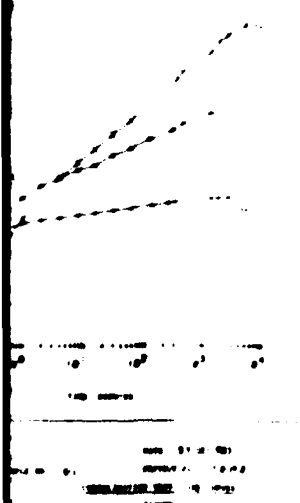

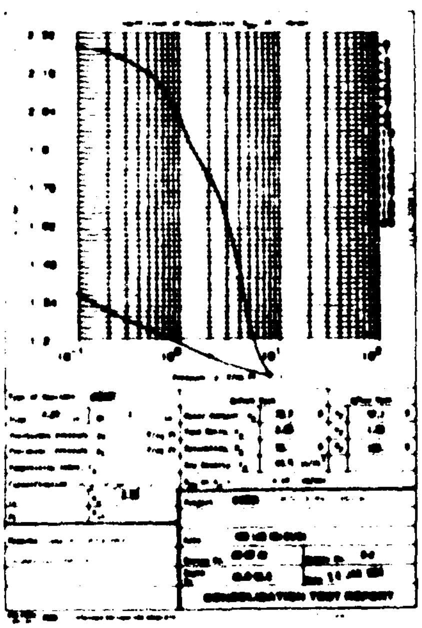

DEPARTMENT OF THE ARMY

FLOOD CONTROL MINNESOTA RIVER

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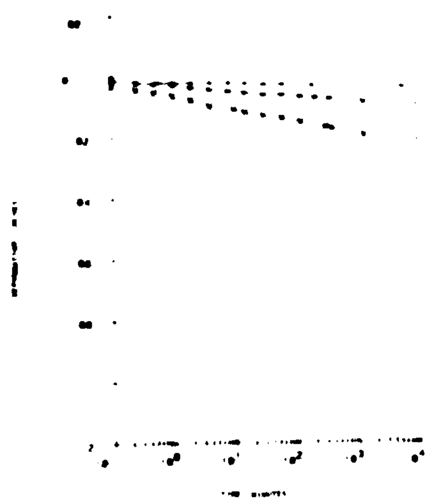
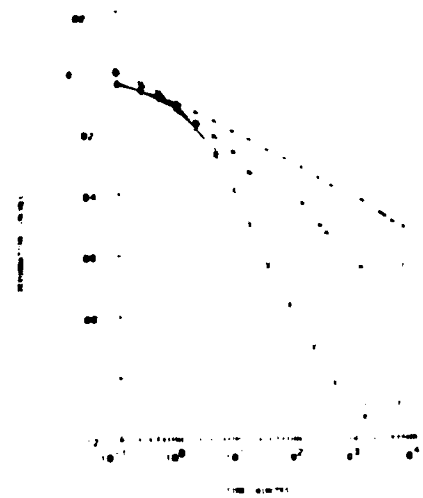
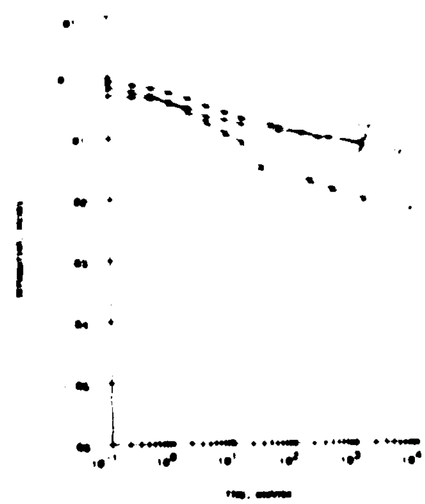
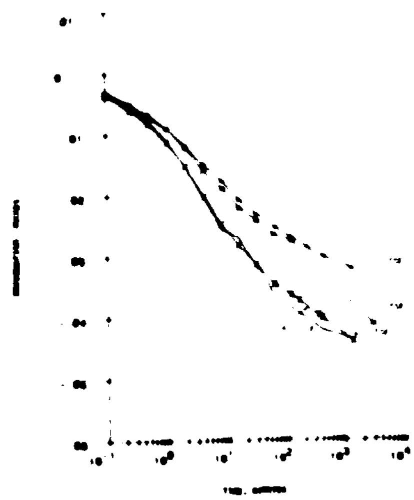
CONSOLIDATION TEST

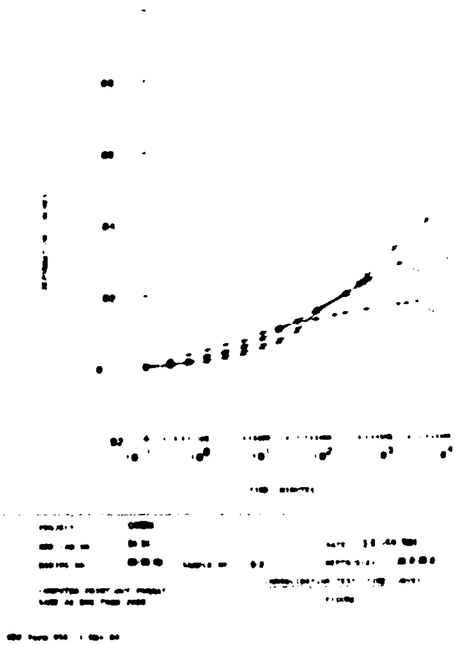
PLATE C-3[illegible]

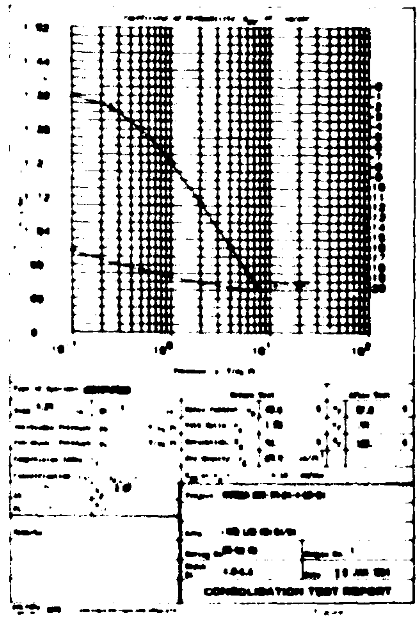


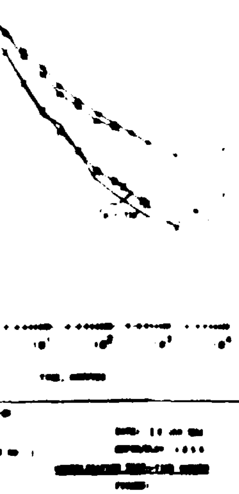












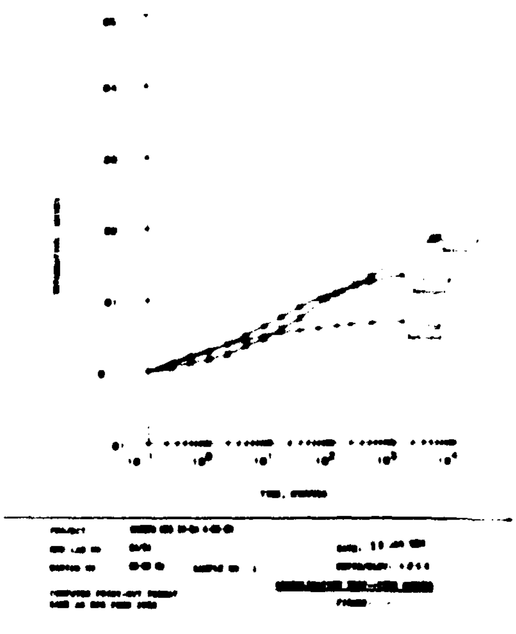


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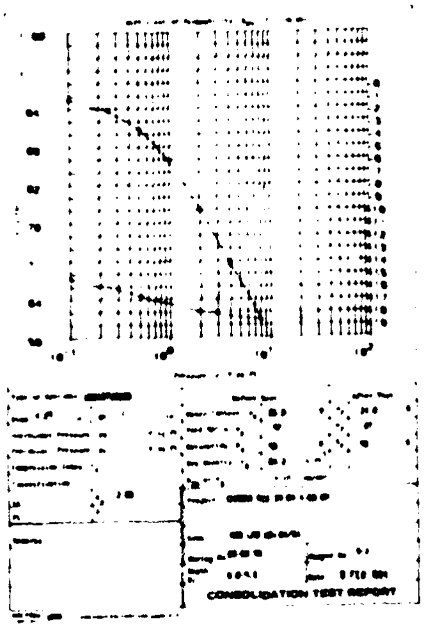
PLATE C-[illegible]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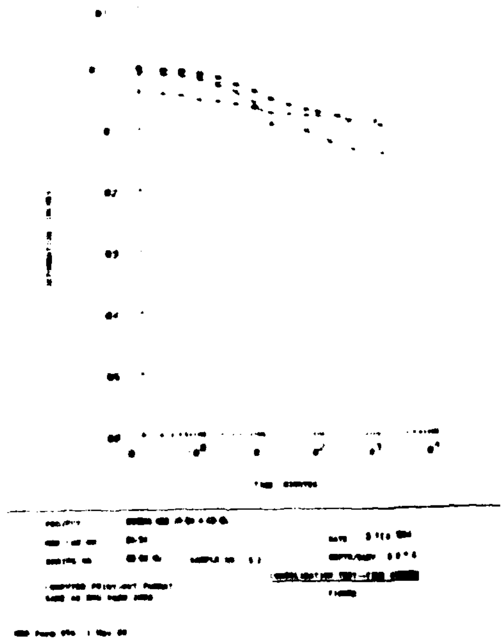
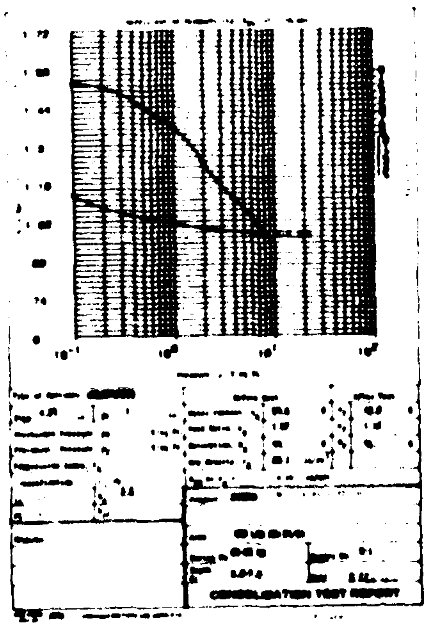
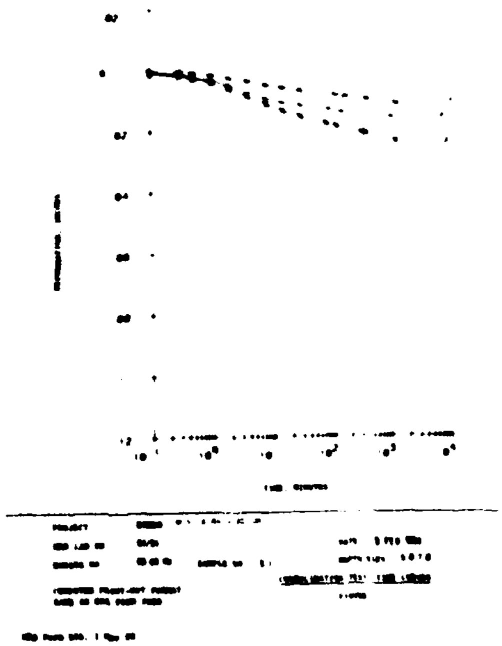
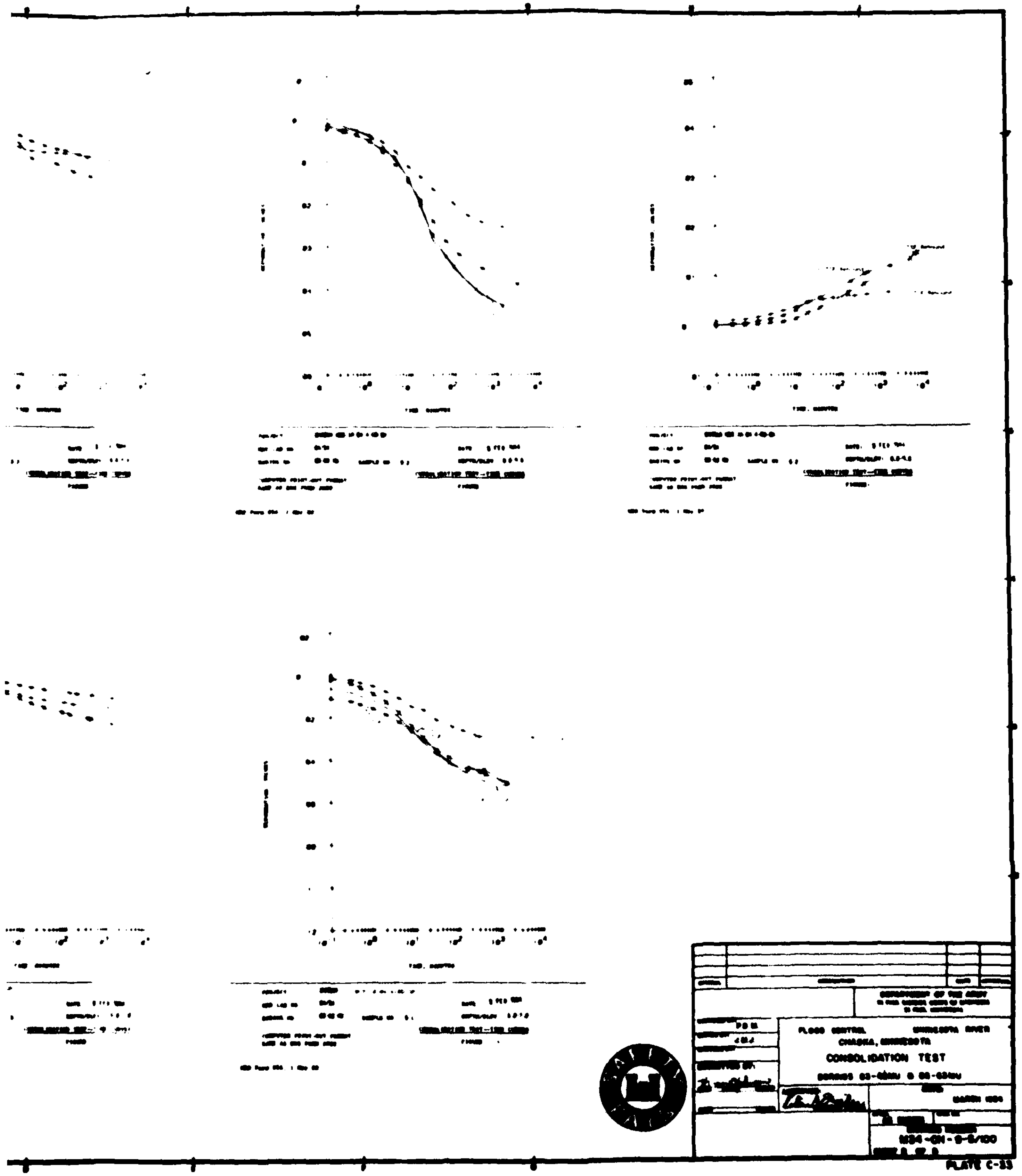


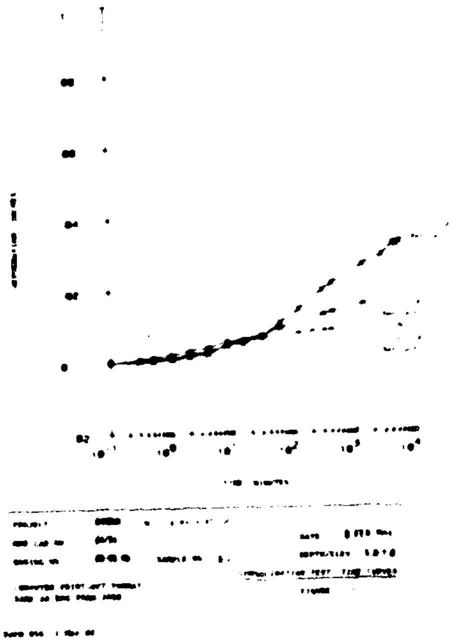

CONSOLIDATION TEST REPORT

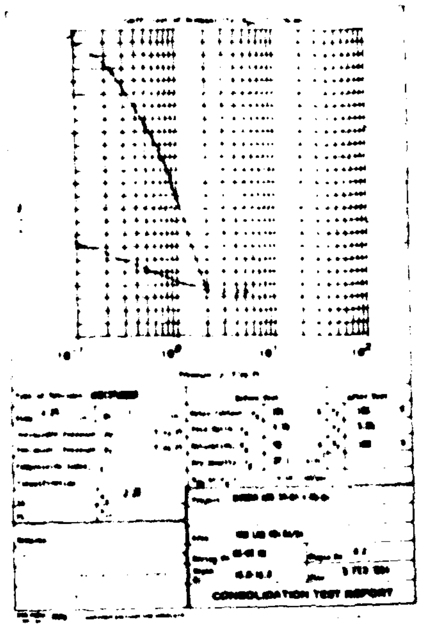




CONSOLIDATION TEST

PLATE C-33

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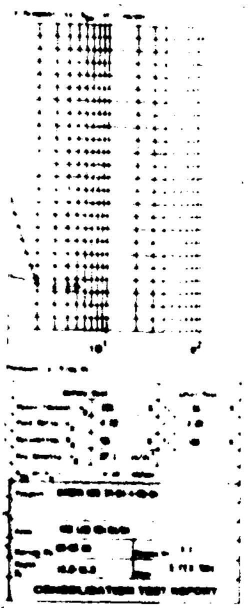

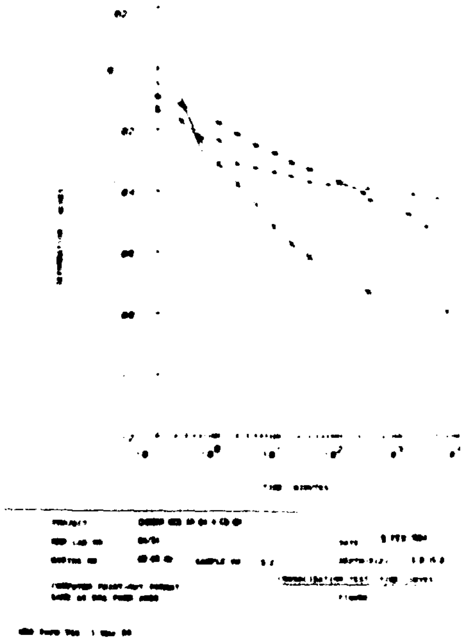

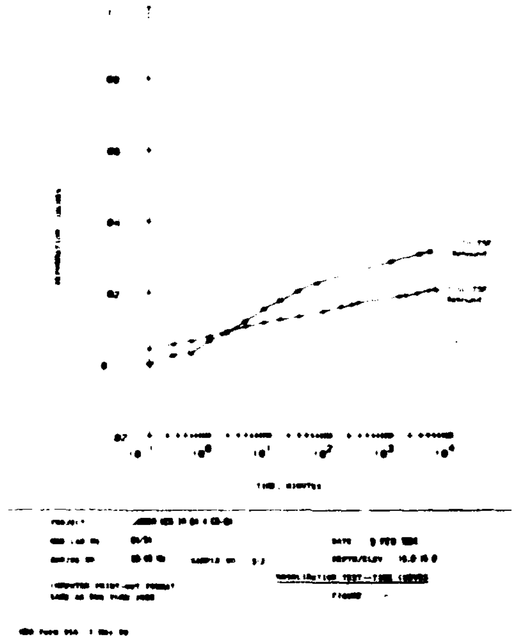

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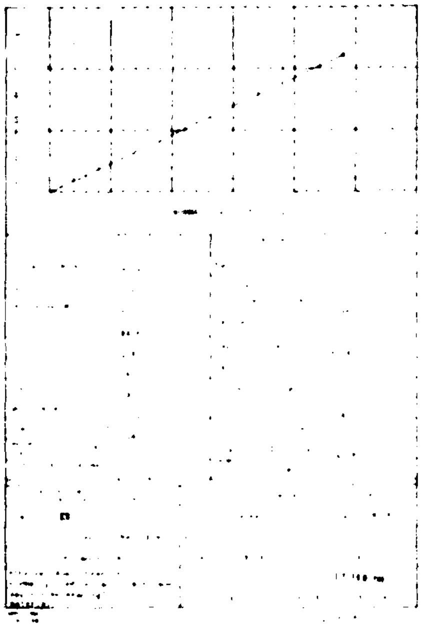
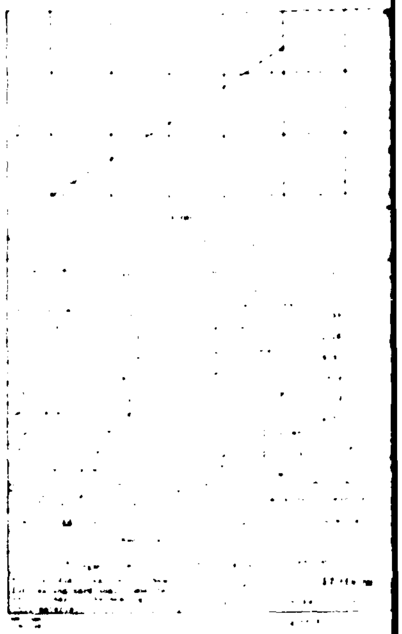
PLATE C-34





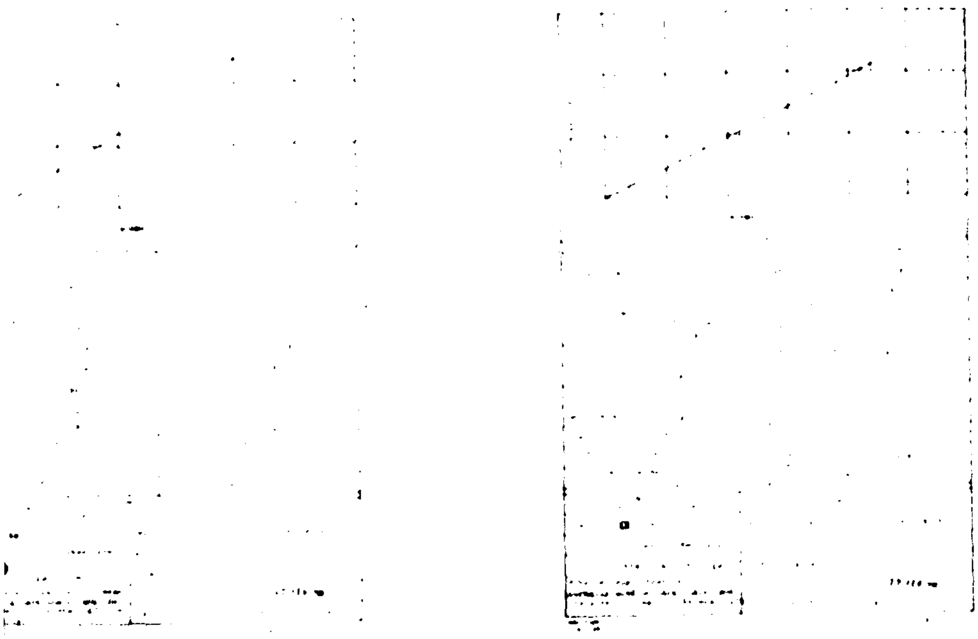


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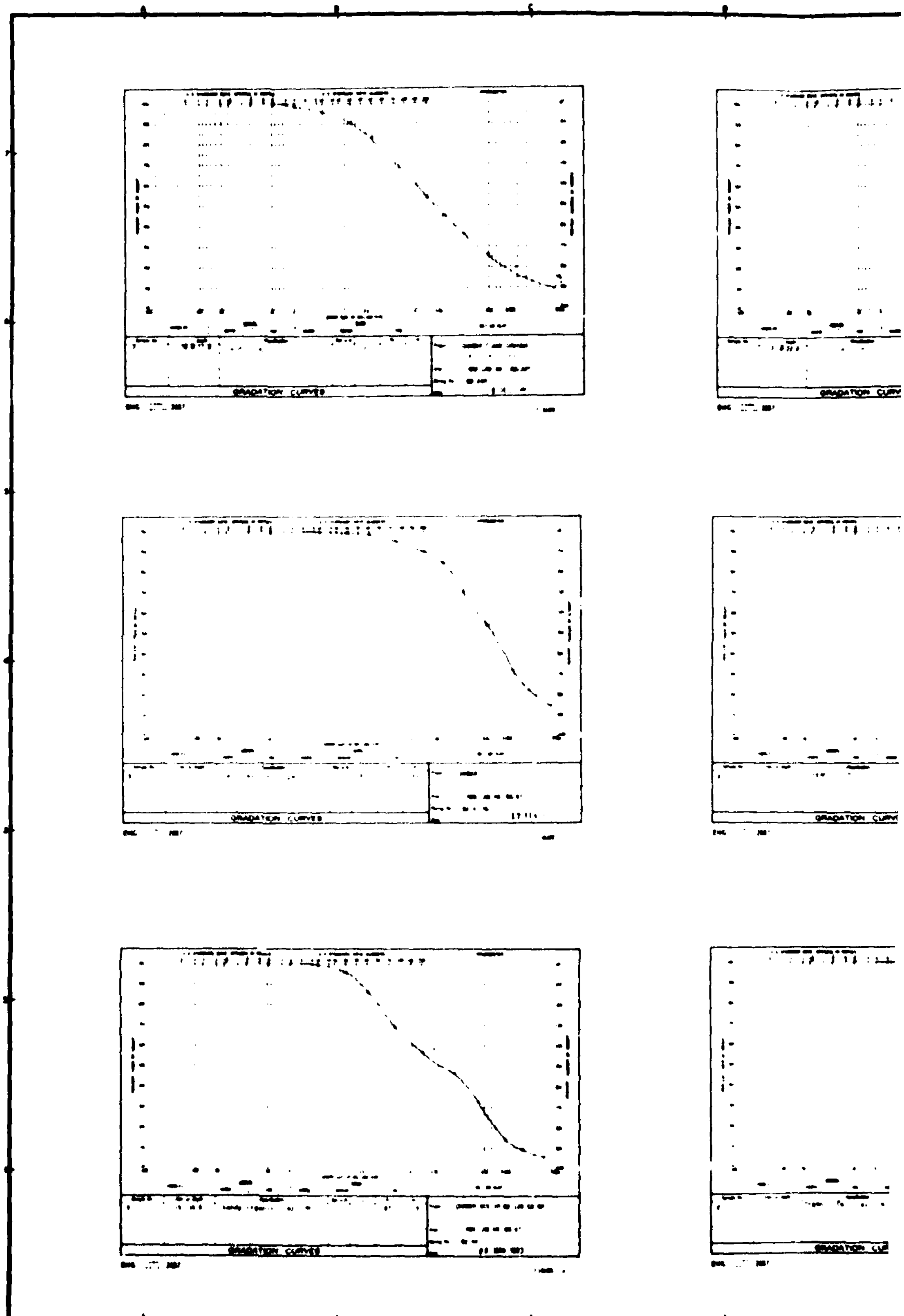
PLATE C-35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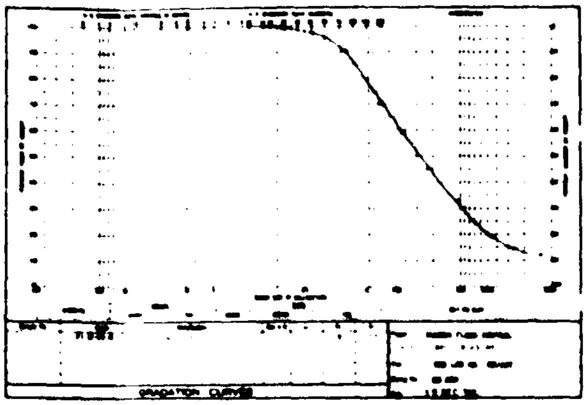

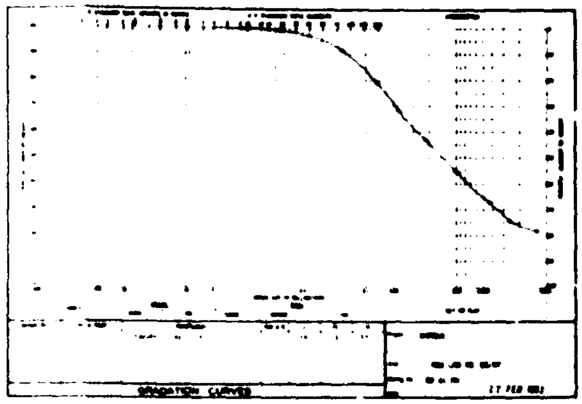

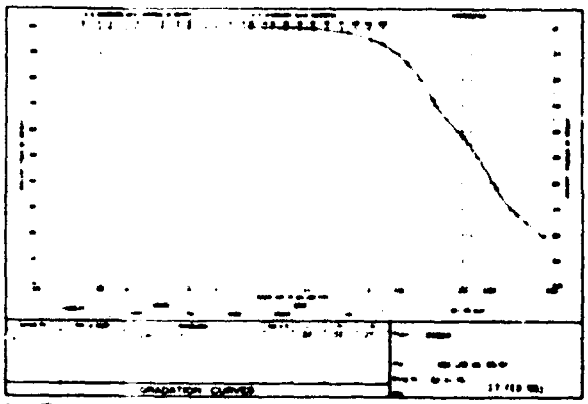

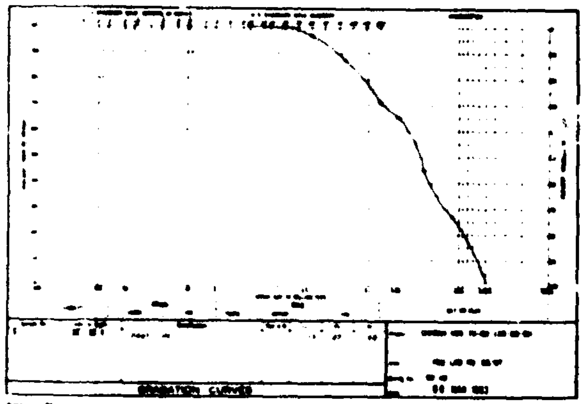

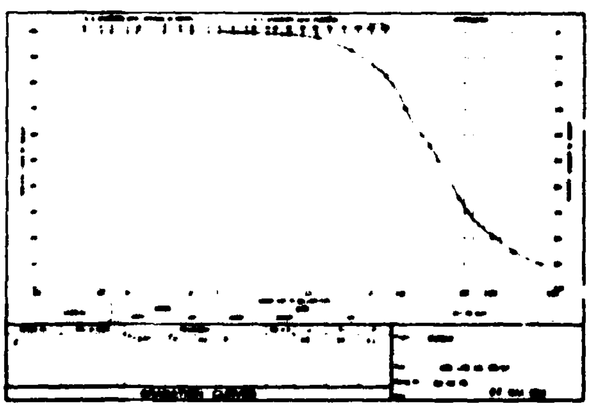

FLOOD CONTROL MINNESOTA RIVER
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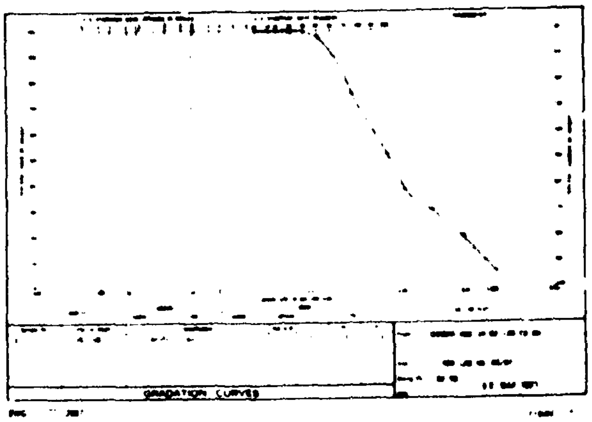
GRADATION CURVES

PLATE C-58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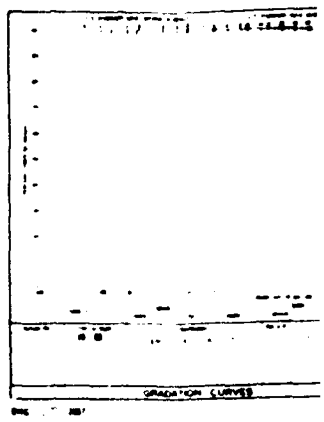
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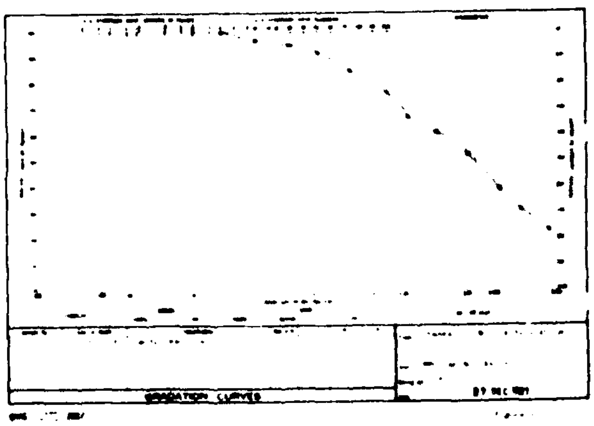
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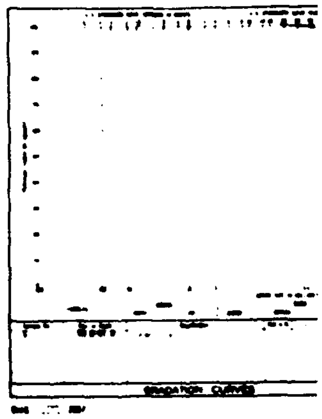
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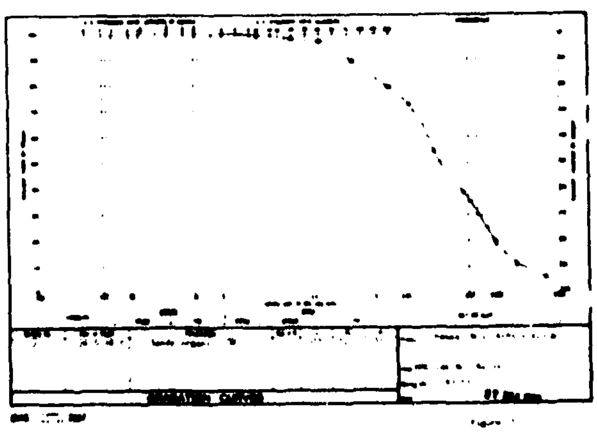
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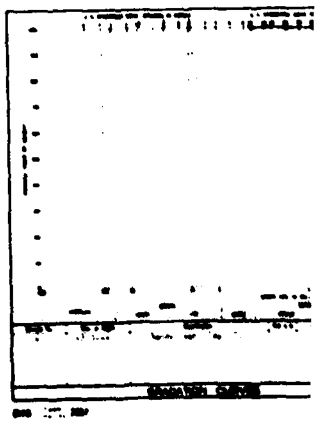
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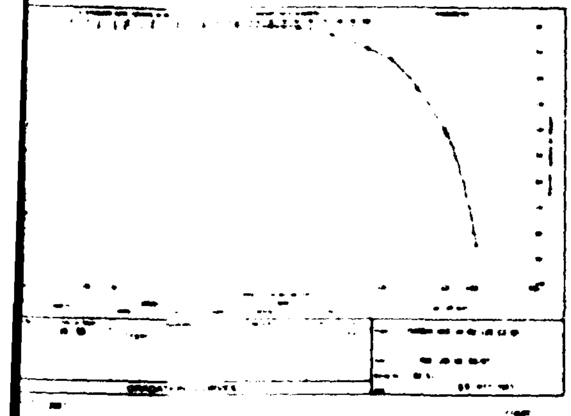

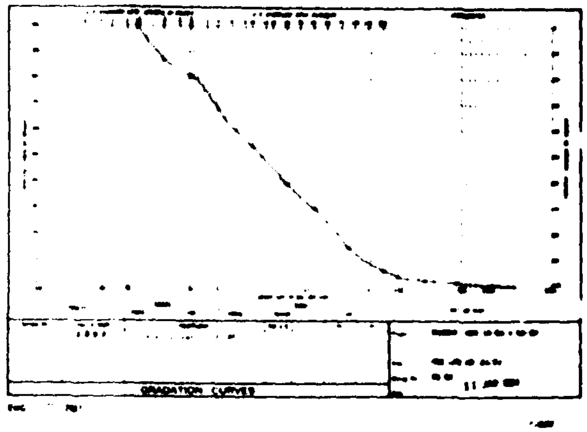

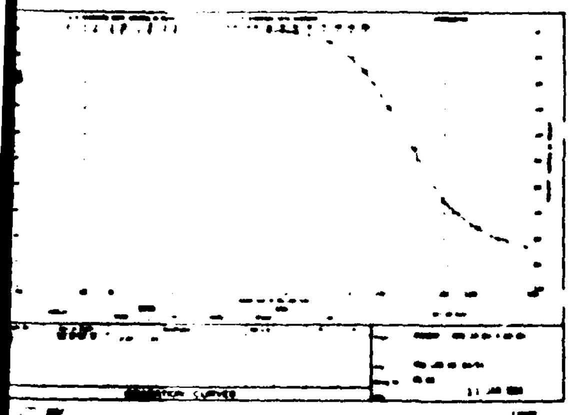

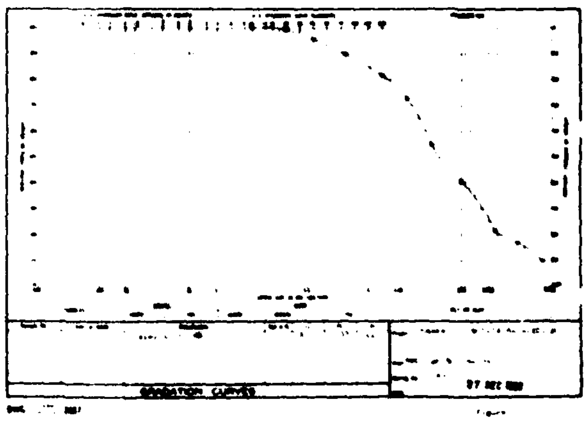

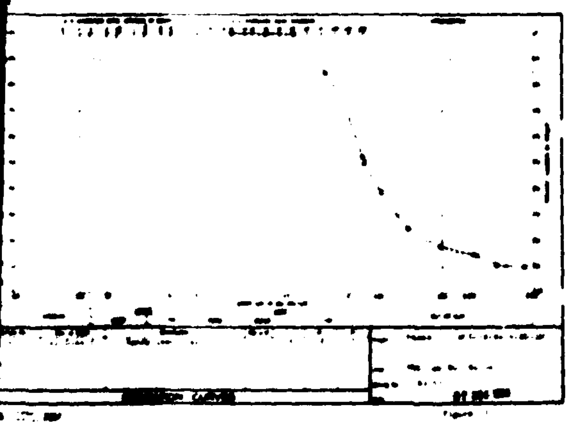

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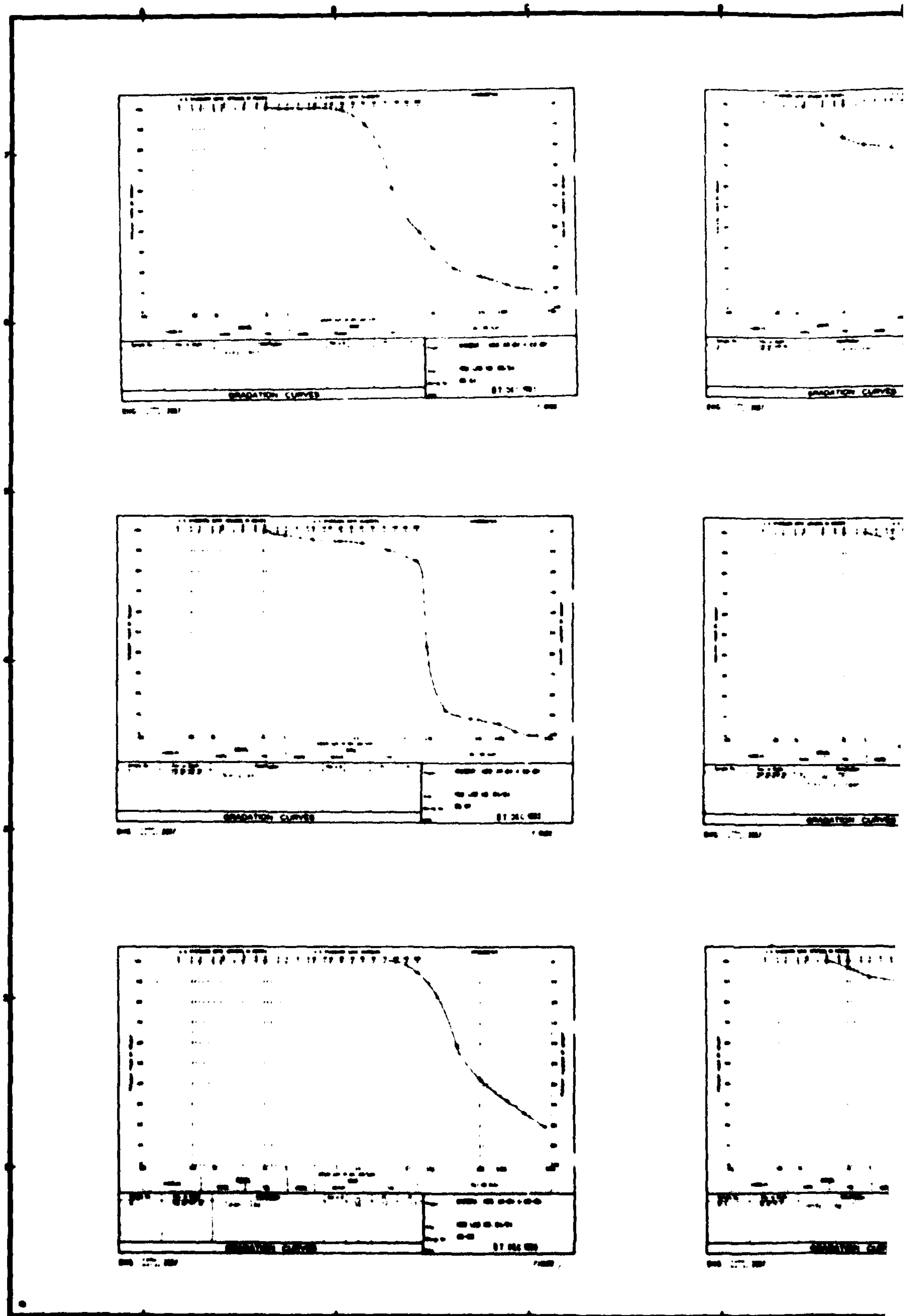
PLATE C-37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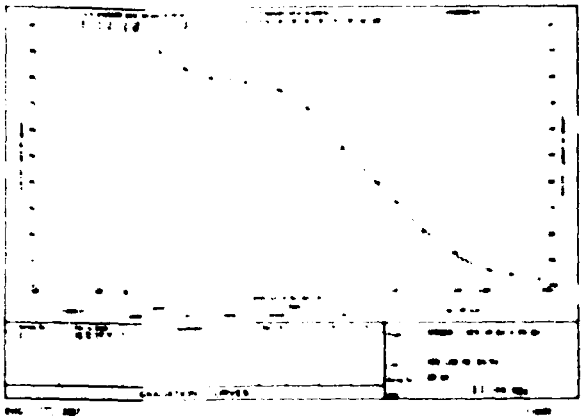

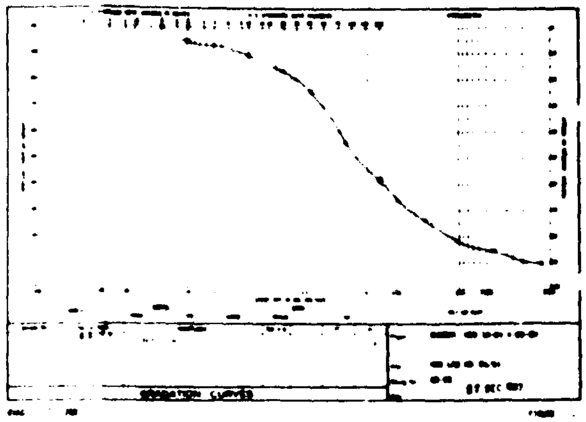

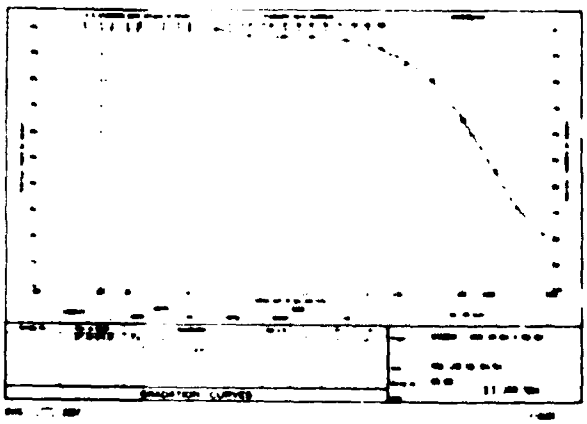

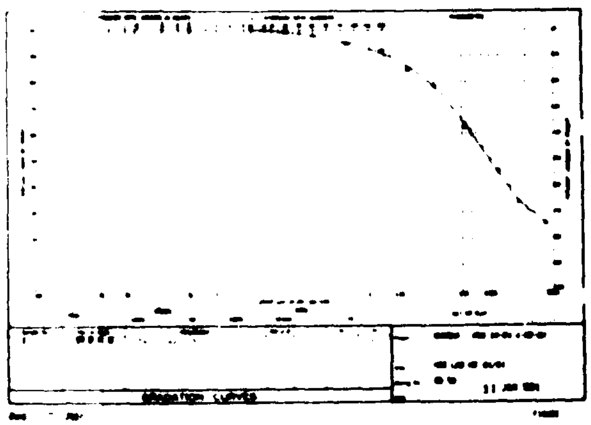

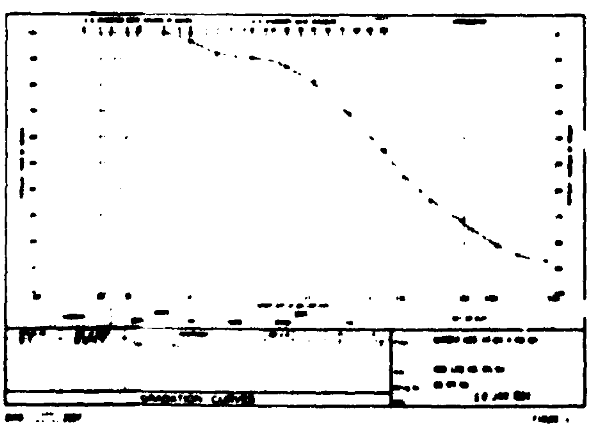

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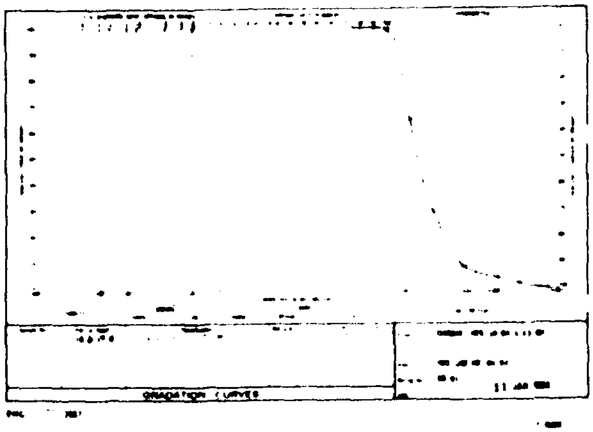
PLATE C-30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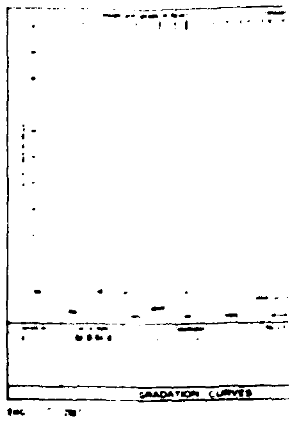
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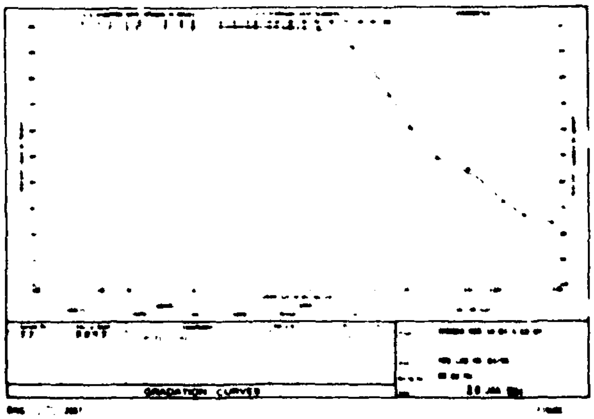
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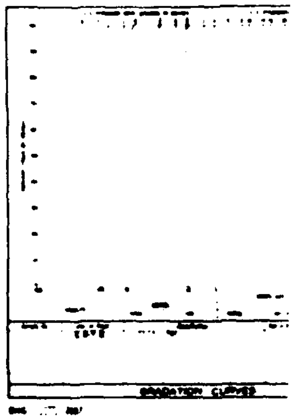
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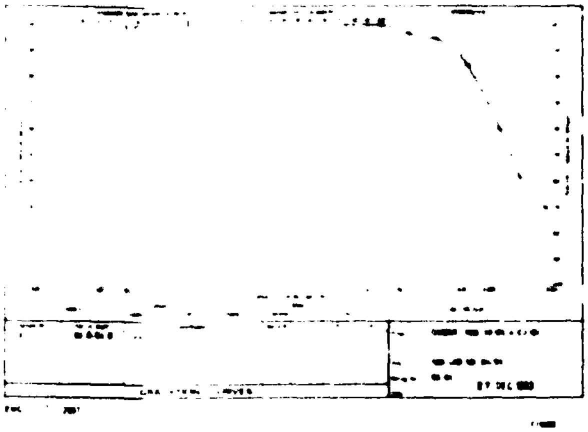

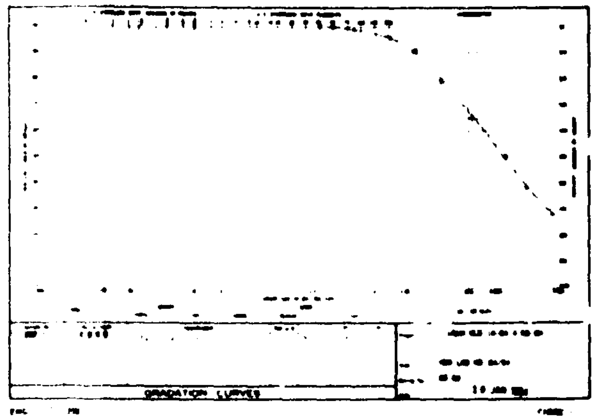

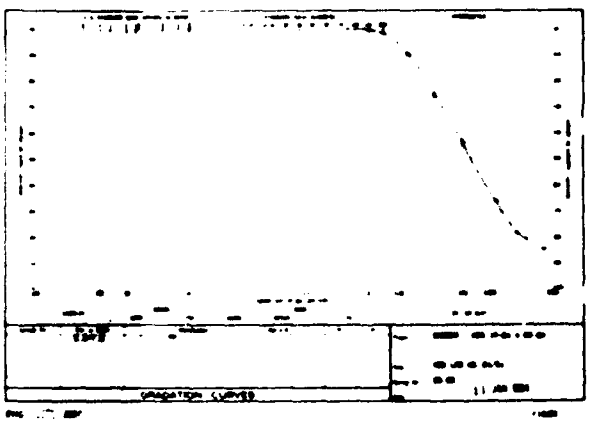

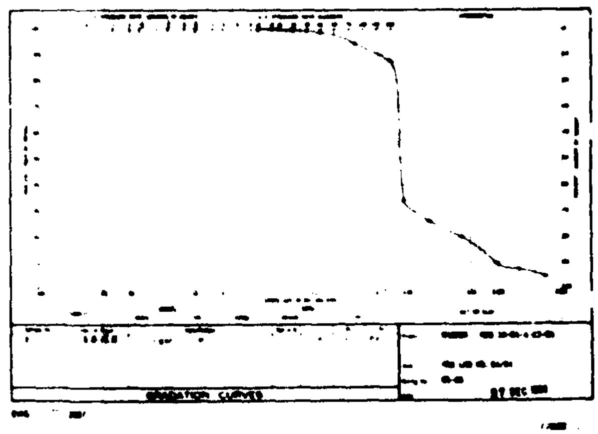

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PLATE C-30

SOIL CLASSIFICATION RECORD SHEET

Project | Boring No. | Depth to Water Table

Gradation Curve Analysis | Classification | Remarks

Table

SOIL CLASSIFICATION RECORD SHEET

Project | Boring No. | Depth to Water Table

Gradation Curve Analysis | Classification | Remarks

Table

SOIL CLASSIFICATION RECORD SHEET

Project | Boring No. | Depth to Water Table

Gradation Curve Analysis | Classification | Remarks

Table

SOIL CLASSIFICATION RECORD SHEET

SOIL CLASSIFICATION RECORD SHEET

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SOIL CLASSIFICATION TEST

SOIL CLASSIFICATION RECORD SHEET

SOIL CLASSIFICATION RECORD SHEET

SOIL CLASSIFICATION RECORD SHEET

SOIL CLASSIFICATION RECORD SHEET

Sample No.	Depth to Bottom of Sample	Water Content (%)	Plasticity LL	Plasticity PI	Grading (Cumulative Percent Finer)	Gradation Curve Analysis	Classification	Remarks
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

SOIL CLASSIFICATION RECORD SHEET

Sample No.	Depth to Bottom of Sample	Water Content (%)	Plasticity LL	Plasticity PI	Grading (Cumulative Percent Finer)	Gradation Curve Analysis	Classification	Remarks
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

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J.H.M.

FLOOD CONTROL MINNESOTA RIVER

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SOIL CLASSIFICATION TEST

BORINGS [illegible] TO [illegible]

MARCH [illegible]

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PLATE C-41

SOIL CLASSIFICATION RECORD SHEET

SOIL CLASSIFICATION RECORD SHEET

SOIL CLASSIFICATION RECORD SHEET

SOIL CLASSIFICATION RECORD SHEET

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CHASKA, MINNESOTA

SOIL CLASSIFICATION TEST

M34-CH-R5/109

PLATE C-42

APPENDIX B

STRUCTURAL

APPENDIX D
STRUCTURAL

1. The design of the structures for the Chaska Project was of a preliminary nature since a Feature Design Memorandum will be prepared for each project feature.

2. The overall diminsion and concrete thicknesses are given in Table 1.

TABLE 1
STRUCTURAL DIMENSIONS

STRUCTURE	Length feet	Width feet	Height feet	Slab Thicknesses Bottom	Sides	Top
Chaska Creek						
Drop Structure STA 19+00	83.24	37.5	24	3.5'	2.0'to4.0'	
Concrete Channel						
35'	1760	35	9	2.5'	1.5'to2.5'	
37.5'	2690	37.5	9	2.5'	1.5'to2.5'	
Drop Structure STA 65+00	187	35	20	3.5'	1.5'to3.5'	
Hickory St. Drainage Channel						
Side Inlet Channel	120'	9'	4.2	3.0'	2.5'	
Concrete Channel						
Rapid Flow	500	9'	6.2	2.0'	2.0'	
Tranquil Flow	160	9'	9.7'	2.0'	2.0'	
Drop Structure	35'	9'	18.9'	2.0'	2.0'	
East Creek						
Control Structure STA9+00	40.5	90	40.5-32.5	5.0'	2.5'to 3.0'	
Stilling Basin STA 9+00	165.3	33.6	22	5.0'	1.5'to5.0'	
16'X16' Box Culvert	1469	16'	16'	3.0'	3.0'	3.0'
Inlet Structure STA 38+35	56'	40'	25'	3.0'	3.0'	
Transition STA 80+00 to81+60	160	50 to 70	14'	3'-0"	1'-6"to2'-6"	
Concrete Channel	566	50'	12'	2'-6"	1'-6"to2'-6"	
Transition STA 87+26	60'	50 to 70		3'-0"	1'-6"to2'-6"	
Drop Structure STA 88+30	43"	70"	21.3to33.5 13.3	5'-0"	2'-0"to5'-0"	

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APPENDIX E

ECONOMIC ANALYSIS

INTRODUCTION

Flooding in Chaska, Minnesota results in three types of economic damages: physical damages, income losses, and emergency costs. Physical damages include damages to floodplain structures and their contents, and losses of roads, sewers, and other utilities. Income losses include loss of wages or net profits over and above physical losses, to the extent that such losses are not compensated by transfer of economic activity to other establishments or postponement of the activity. Emergency costs include costs of evacuation and reoccupation, flood fighting, and disaster relief.

Damages in each of these three categories is associated with the land use of the area. Past development of the Minnesota River floodplain has occurred in portions of the city subject to flooding. Such development has taken place because people have deemed the advantages of the floodplain to be greater than the disadvantage of flood vulnerability and because knowledge of the flood hazard has been incomplete.

Flood reduction measures would release those economic resources -- land, labor, and capital -- used to fight floods and to repair or replace flood-damaged properties. Hence, damage reduction would benefit national economic development (NED).

This appendix will estimate flood damages incurred in Chaska and the NED benefits of measures proposed to reduce those damages. This benefits analysis is in accordance with the U.S. Water Recource Council's Procedures Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies. The project life for flood damage reduction plans is 100 years and the base year is 1990. Analysis uses the current Water Resources Council's prescribed Federal discount rate of 8 1/8 percent and October 1983 price levels.

DELINEATION OF AFFECTED AREA

The area within the 1-percent-change floodplain encompasses approximately 390 acres behind the levee and along East and Chaska Creeks. It is virtually fully developed for residential, commercial, and public use. Public facilities in the floodplain include the Carver County courthouse, which contains files of tax, court, and birth and death records. The Chaska wastewater treatment plant, which serves the city and has a rated capacity of 1.4 million gallons per day is also in the floodplain. The presence of the courthouse and the wastewater

treatment plant in the floodplain means that the area potentially affected by flooding includes all of Chaska, and indeed all of Carver County.

The 1980 population of Carver County was 37,046, and the total population of Chaska was 8,346. The 1-percent-chance floodplain population is estimated at 1500, based on the number of housing units located in that part of the city. Population data is summarized in the following table.

POPULATION DATA FOR CHASKA, CARVER COUNTY AND THE TWIN CITIES, 1970-1980

Area	Population 1970	1980	Percentage Change
Chaska Floodplain Areas	1,800	1,500	-16.7
Chaska	4,352	8,346	91.8
Carver County	28,331	37,046	30.8
Twin Cities 7-County Metropolitan Area(1)	1,874,452	1,985,705	5.9

(1) Anoka, Carver, Dakota, Hennepin, Ramsey, Scott and Washington Counties Sources: Bureau of the Census
Corps of Engineers for Floodplain Population Estimates

The data indicate that population in Chaska has grown at an annual compounded rate of about 6 1/2 percent since 1970. Growth in Chaska accounts for nearly one-half of the 1970-1980 increase in the population of Carver County. The decrease in the estimated floodplain population is due to decreases in the average number of persons per unit of housing. This decrease is a metropolitan-wide phenomenon: the ratio of persons to housing units in the 7-county area has declined from 3.2 in 1970 to 2.7 in 1980, according to the Twin Cities Metropolitan Council.

FLOODPLAIN CHARACTERISTICS

Chaska is subject to flooding from three sources: the Minnesota River, Chaska Creek, and East Creek. This section will describe the characteristics of each floodplain. A map of the floodplain areas is included in the main report.

Minnesota River Floodplain

The Minnesota River floodplain encompasses 100 acres behind the existing city levee and is fully developed. It includes 353 homes, 21 commercial establishments, and 2 public buildings. The total value of floodplain structures is estimated at $26 million.

Development in the floodplain dates back to 1854 and was influenced by the ready availability of waterborne transportation. Chaska's early growth was linked with its role as a steamboat landing. Railroad construction diminished this role but encouraged further growth in flood-prone areas because the railroads were built in the floodplains and terraces of the Minnesota River valley. The Chicago and North Western Railroads both passed through the older part of the town. U.S. Highway 212, the main highway connecting Chaska with Minneapolis, was built some years later along a route parallel to the railroads.

Homes in the floodplain have a median age of 75 years. Development in the floodplain in the past 20 years has consisted only of filling in a few remaining vacant lots. The homes are of wood-frame or brick construction and are built on 1/4-acre lots. Although many of these structures were flooded in 1965 to great depths, the structures are in good condition. Additions are common, and many have been rehabilitated within the last decade. According to assessor's data, the average structure value is approximately $51,300.

Commercial development consists of small shops and offices located on Chestnut Street (Minnesota Highway 41) or dispersed through the floodplain area. Public facilities are the wastewater treatment plan and the county courthouse, which was built in 1963.

A levee was built by the city after the 1952 flood and was intended to protect against a 5-percent frequency flood. The levee was overtopped in 1965, restored by the Corps, and was subsequently raised about 4 feet by the city. It was raised another 2 feet prior to the 1969 flood, and was successful in preventing damages from that event. The levee is not constructed to Corps design standards and is considered an inadequate flood control measure, but its presence has no doubt enhanced residents' perceptions of the desirability of the floodplain. For further information on the reliability of the emergency levee, see Appendix I.

When the emergency levee failed during the 1965 flood, extensive damages occurred in this area. 181 homes were evacuated for an average of 33 days. Seventeen homes were flooded to the second floor or attic level, 136 had first-floor flooding, and an additional 80 had basement flooding. Total damages at the time were $1.7 million. The same event would cause an estimated $9.3 million in damages today. Other major floods occurred in 1969, 1968, 1957, 1952, and 1951. Further information on these flood events is presented in the main report.

Chaska Creek Floodplain

The analysis divided the Chaska Creek floodplain into 2 subareas, separated by Highway 212. The downstream portion, which can be flooded by the Minnesota River as well as Chaska Creek, is the principal damage area. It includes 194 homes and 6 businesses with an estimated structure value total of 10.9 million. The upstream portion includes 10 homes. Structures in the upstream portion have an estimated value of $565,000.

The downstream portion of the Chaska Creek floodplain is subject to relatively high damage because it is a densely developed area and because floodwaters spill over an interior drainage divide and pond in the area, behind the city emergency levee. Ponding depths can reach 10 feet for the 1-percent frequency event.

Flooding was reported for this area in July 1951, but no information is available on any resulting damages. No ponding occurred, as the city levee was not in place at the time.

East Creek Floodplain

The East Creek floodplain consists of two subareas: the portion downstream of Highway 212, which is also subject to Minnesota River flooding, and the portion upstream from Highway 212 along the valley terrace. The downstream portion includes 18 homes with a total structure value of $0.8 million. Upstream are 160 dwelling units (89 housing structures) in the terrace area bounded by the Creek, Crosstown Boulevard, Highway 212, and County Road 17; 15 businesses (strip development) north of Highway 212 and west of Crosstown Boulevard; and a city fire station. Structure value for the upstream area is estimated at $12.1 million.

The homes in the terrace area are one-story ramblers built 20-25 years ago. The site has the advantage of ready access to Highway 212 (and, hence, to Minneapolis and suburbs) and proximity to the older part of the city. Knowledge of the flood hazard was probably not widespread when the homes were first sold. Assessor's sales records indicate the average structure value for the single-family homes is $60,000.

Commercial development includes small stores and offices; restaurants; and boat, farm implement, and automobile dealers. These firms are dependent on automobile traffic along Highway 212. Their facilities were constructed before knowledge of the flood hazard was common.

The last major flood on the creek occurred in July 1951, prior to construction of the residences and commercial buildings. Potential flood depths are about 2-4 feet above ground level for the 1-percent frequency event.

Summary

Total floodplain development includes 452 residential structures (503 dwelling units), 36 commercial establishments, and 3 public buildings. The total structure value is 38.7 million. Data on floodplain development are summarized on the following page.

SUMMARY DATA ON CHASKA FLOODPLAIN, EXISTING CONDITIONS

Floodplain	Number of Structures Residential	Commercial	Public	Total Structure Value (millions)	Maximum Flood Depths, 0.1-percent frequency event (feet)
Minnesota River	353	21	2	26.0	14
Chaska Within Minnesota River Floodplain	194	6	0	10.9	10
Outside of Minnesota River Floodplain	10	0	0	0.6	3
Total	204	6	0	11.5	--
East Creek Within Minnesota River Floodplain	18	0	0	0.9	2
Outside of Minnesota River floodplain	95	15	1	12.1	4
Total	113	15	1	13.0	--
GRAND TOTAL(2)	458(3)	36	3	38.7	--

(1) Behind existing levee

(2) Without double-counting of acres and structures in more than one floodplain

(3) 503 dwelling units are contained in these structures

FUTURE CONDITIONS

Floodplain Areas

Little change has been seen in the last decade within floodplain areas, and little change is expected in the future. Population density may level off, additional homes may be refurbished, and businesses may come or go, but the overall expectation is that development in the floodplain will look much the same 25 years from now as it does today.

However, real per-capita income is expected to change within the study area. 1980 OBERS Regional Projections, published by the Water Resources Council and shown in the table below, project per capita income in the Minneapolis-St. Paul area to increase from $5,947 in 1978 to $17,725 in 2030 (1972 dollars). This implies an annual rate of growth of 2 1/8 percent, compounded. With increased income, the value of furnishings and personal belongings in each flood-prone house would be expected to increase, and total damage for a given flood event would rise. The increase in damages from economic changes will be evaluated in a later section.

OBERS SERIES # PROJECTIONS OF REAL PER-CAPITA INCOME, MINNEAPOLIS-ST. PAUL SMSA(1), 1970-2020

	1978	1990	2000	2030
Per-capita Income(2)	5,947	8,320	10,230	17,725
Factor Change	1.000	1.39	1.72	2.98

(1) Standard Metropolitan Statistical Area

(2) Constant 1972 dollars

Upland Areas

Though changes in the floodplain are projected to be minor and of no relevance to flood damage, development in the upland portions of the creek watersheds are of great significance to downstream flood potential. Therefore, detailed projections of population, employment, and land use have been developed for these areas.

Much of the East Creek watershed is within the boundaries of Jonathan, a new-town project proposed by local investors and the Federal Department of Housing and Urban Development (HUD) in 1970. The project called for the construction of 15,286 dwelling units over a 20-

year period to house about 46,000 people in a self-contained community. Projections noted in the 1973 feasibility report were for a total Chaska population of 80,000 by the year 2000.

HUD issued grants of $4.5 million for planning, water and sewer system extensions, and purchase of open space, and guaranteed $21 million in debentures issued by the investors, but the development company failed in the mid-1970's. HUD began foreclosure proceedings in August 1978, acquired the property, and sold it in 1980. Current development consists of about 900 residential units approximately 166,000 square feet of commercial space, and nearly 1 million square feet of industrial space.

While growth in the area will not meet the goals set in 1970, development to a lesser degree will occur in the East Creek watershed and has implications for future runoff conditions and flood frequencies for the downstream floodplain. In October 1977 the Twin Cities Metropolitan Council developed projections of population, employment, and housing units for Chaska and all other municipalities in the seven-county region, and mandated use of the projections for the development of community comprehensive plans. The Metropolitan Council projections are consistent with 1980 OBERS projections developed for the Water Resources Council. Chaska is now expected to have a population of 22,5000 by the year 2000. A summary of the projections, with straight-line extrapolations from 2000 to 2030, is shown in the following table.

PROJECTIONS OF POPULATIONS, EMPLOYMENT, AND HOUSING UNITS WITHIN CHASKA CITY LIMITS

Item	1970 (Actual)	1980 (Actual)	2000 (Projected)	2030 (Projected)
Population	4,352	8,346	22,500	40,500
Employment	1,249	4,000(1)	8,500	15,500
Housing units	1,299	3,094	8,000	14,700

(1) Estimated

Sources: Metropolitan Council for data through 2000
Corps of Engineers for extrapolation to 2030

The city's draft comprehensive plan, dated December 1980, notes capability of the East Creek watershed to house a population of 40,000. Since sewer and water lines have already been extended through this area, practically all new development through 2030 is expected to be in the East Creek watershed. An allocation of housing units and school, office, industrial park, and shopping space among the 9 East Creek subwatersheds was made based on field inspection, discussions with the city planner, and consultation of the 3-volume Jonathan New Community Draft Environmental Impact Statement published by HUD in December 1977. The latter describes in detail six alternate development paths for the area. A map of the 9 East Creek subwatersheds appears in Appendix 4. Among the assumptions for the allocation are the following:

o Approximately 10,000 housing units will be constructed in East Creek subareas E1-E9 by the year 2030. This will include 5,000 single-family homes, 625 townhouses with 4 dwelling units each, and 250 apartment buildings with 10 dwelling units each. The overall average land use density will be 4.7 dwelling units per developed acre, and each dwelling unit will have 3 people.

o In the school/office park/industrial park/shopping area category of land use, 30 percent of the total acreage is expected to be school or office park, with approximately 14,000 square feet of interior space per developed acre, and 65 percent is expected to be industrial park, with approximately 7,500 square feet of interior space per developed acre. Finally, 5 percent is expected to be commercial development (shopping area), with approximately 3,200 square feet of interior space per developed acre. The number of jobs created by development are expected to be 51 per acre, of school or office park, and 9 per acre, of industrial park or shopping area. Parking space would be required accordingly.

o The major highway improvement for the watershed will be the construction of a new Trunk Highway 212. Current plans are for this highway to be a 4-lane, divided, "rural design" freeway with fully controlled access west from Interstate 494 to Trunk Highway 41, and partially controlled access west of Trunk Highway 41. The improvements are considered necessary by the Metropolitan Council to complete the metropolitan highway system.

The resulting allocation is summarized in the following table. These data were used for hydrologic analysis of existing and future conditions on the creek.

Subbasin Number	Total Area (acres)	Lake Area (acres)	PRESENT CONDITIONS (1983) Residentail (acres)	School & Office and Industrial Park & Shopping (acres)	Agriculture, Golf, Park, Open Space (acres)	FUTURE CONDITIONS (2000) Residentail (acres)	School & Office and Industrial Park & Shopping (acres)	Agrigulture, Golf, Park, Open Space (acres)
E1	836 (1.31 mi^2)	0	80	17	739	298	31	507
E2	336 (0.52 mi^2)	0	113	0	223	225	0	111
E3	1,072 (1.68 mi^2)	0	143	0	929	497	66	509
E4	762 (1.19 mi^2)	156	24	0	582	163	0	443
E5	1,324 (2.06 mi^2)	0	6	0	1,318	420	9	895
E6	434 (0.68 mi^2)	32	18	7	377	215	40	147
E7	500 (0.78 mi^2)	0	0	73	427	0	273	227
E8	538 (0.84 mi^2)	154	14	56	314	64	165	155
E9	572 (0.89 mi^2)	21	0	0	551	258	19	274
TOTAL	6,374 (9.95 mi^2)	363	398	153	5,460	2,140	603	3,268

Economic Changes

Flood damages to residential contents are projected to increase at the same rate of change as real per capita income, up to the point where contents value is 75 percent of structure value. In accordance with ER 1105-2-371, no increased damages are calculated for increased structure value. Currently, contents value is estimated at 29 percent of structure value. (Study for the 1973 Feasibility Report indicated contents value at 25 percent of structure value, and data in the April 1980 Survey of Current Business indicated the actual Minneapolis-St. Paul annual growth rate in real per-capita income for 1973-78 was 2.3 percent. $0.25 \times 1.023^{10} = 0.31$). Therefore, contents value will increase by a factor of 2.42 (0.75 divided by 0.31). Since real per-capita income is projected to grow at a 2.5 percent compounded annual rate, contents value will be 75 percent of structure value in 37 years (1.025^{37} 2.42). The net factor increase for year 37 in residential damage is 1.41 ($0.29 \times 2.42 + 0.71 \times 1.000$). Therefore, input for the EAD program was coded to show a factor increase of 1.41 in residential damages for year 2020, which is 37 years form 1983.

No future growth is projected for commercial or public damage. The floodplains are fully developed and no empirical evidence is available to project increases in contents and inventories of commercial and public structures.

Hydrologic and Hydraulic Changes

Hydrologic and hydraulic conditions are projected to change over the next 50 years with upstream development in the creek watersheds and slow aggravation of the Minnesota River channel. Analysis of these changes are described in Appendix A, Hydrology and Hydraulics. Discharge-frequency and stage-frequency curves for future conditions, year 2030, have been entered as input to the EAD model in order to compute increases in damages from hydrologic and hydraulic changes.

FLOOD DAMAGES WITHOUT THE PROJECT

Present Conditions

Flood damages have been evaluated for present conditions using records from the 1965 flood, a floodplain structure inventory, 2-foot contour topographic maps, depth-damage curves, interviews with business people and public officials, and data from the flood emergency preparedness plan prepared by the city. Inventories of capital improvements in the floodplain were conducted in 1980, and included listings of value, ground elevation, first floor elevation, and location relative to the river or creek channel. These data were updated in 1984 and were used to derive stage-damage and discharge-damage curves for each of three damage categories in each of five damages reaches. Average annual losses are estimated using standard

damage-frequency integration techniques and the Expected Annual Damage (EAD) computer program developed at the Hydrologic Engineering Center. A complete description of the general principles of calculating average annual damages is presented in the users' manual for the program.

Damages are classified as residential, commercial, or public. Residential losses include physical damages to dwellings and their contents and to other personal property. Losses to commercial establishments include physical damages to buildings, equipment, and inventories. Public losses include physical damage to public buildings, streets, sewers, and sewer treatment facilities, and the costs for labor, material, and public relief during flood emergencies.

Damage Reaches

Five damage reaches have been established for the floodplain areas. The five reaches are the areas affected by: (1) Minnesota River flooding, (2) direct flooding from Chaska Creek, (3) ponding behind the existing levee from Chaska Creek overflow, (4) East Creek flooding upstream of Highway 212, and (5) East Creek flooding downstream of Highway 212. Basic information on each reach is presented below.

FLOOD DAMAGE REACHES AT CHASKA

Reach Number	Reach Description	Zero Damage Elevation or Discharge	Zero Damage Exceedance Frequency (percent)
1	Minnesota River flooding	W.S. 709.0 Minnesota River	27
2	Chaska Creek direct flooding	1500 c.f.s. Chaska Creek	30
3	Ponding from Chaska Creek overflow	1500 c.f.s. Chaska Creek	30
4	East Creek, upstream of 212	[illegible] c.f.s. East Creek	64
5	East Creek, downstream of 212	1850 c.f.s. East Creek	14

Damages are analysed in two ways, with and without the existing levee in place. The existing levee protects against damages from the Minnesota River some of the lower level flooding from East Creek. When analyzing the levee, credit was given to elevation 712.5 along the River and other higher elevations along East Creek, as noted in Appendix A.

The levee can also cause interior flood damages in Chaska because of inadequate pumping. The damages caused by the ponding of flood water from Chaska Creek is now greater than the protection provided by the emergency levee. Interior flooding damages are expected to increase from $1,806,000 to $2,627,000 with future development.

Residential Damages

Residential damages have been computed for each reach with the DDS computer program. DDS uses information from HEC-2 output (water surface profiles) and data on house value, elevation, and location to find the depth of flooding at each structure. Calculations are performed for each of six potential flood events, and the results serve as plot points for elevation- or discharge-damage curves.

Residences can be flooded directly, when water flows above ground and into the home, or indirectly, when water seeps into the basement or enters through a sewer drainpipe. The evaluation of residential damage includes indirect damage for Reach 1, Minnesota River flooding. Seepage and back-up are problems for this reach because of soil type, storm sewer configuration, and the long duration of Minnesota River flooding. However, flooding from the Creeks is of short duration and seepage and backup would not occur. Therefore, damage analysis for Reaches 2 - 5 include direct damage only.

Residential damages for present condition are shown below for the 20-, 10-, 1-, and 0.2-percent frequency floods. Also listed are average annual damages by reach. Total average annual residential damages are $1,447,000 for existing conditions and $2,214,000 for future hydraulic and economic conditions. Unit average annual damages for reaches 2 and 4 are high because of a greater frequency of flooding. However, damages for reaches 1 and 3 are much greater for severe flood events because of substantially higher flood depths.

Residential Damages at Chaska
Without Emergency Levee Credit

Reach	20-percent	10-percent	1-percent	0.2-percent	Existing Average Annual Damage	Existing and Future Average Annual Damage
1	$ 200,000	$1,437,000	$ 6,883,000	$11,922,000	$ 453,000	$ 577,000
2	652,000	1,721,000	2,286,000	2,592,000	355,000	715,000
3	55,000	151,000	2,910,000	4,200,000	95,000	190,000
4	400,000	1,150,000	1,486,000	1,698,000	536,000	720,000
5	0	23,000	139,000	230,000	8,000	12,000
Total	$1,307,000	$4,482,000	$13,654,000	$20,642,000	$1,447,000	$2,224,000

Commercial Damages

Commercial damages at Chaska have been evaluated through direct interviews of business owners and manager. The estimates of damages were obtained by calculating the depth of flooding for each of three floods and estimating the damage associated with each depth. The data were then combined for each damage reach. Present conditions damages for the 20-, 10-, 1-, and 0.2-percent frequency events and average annual damages are tabulated below. Average annual commercial damages total $113,000.

Commercial Damges at Chaska
Without Emergency Levee Credit

Reach	Flood Event 20-percent	10-percent	1-percent	0.2-percent	Existing Average Annual Damages	Existing and Future Average Annual Damages
1	0	$ 21,000	$ 565,000	$1,984,000	$ 26,000	$ 29,000
2	0	0	0	0	0	0
3	0	0	192,000	350,000	5,000	7,000
4	25,000	385,000	616,000	600,000	82,000	100,000
5	0	0	0	0	0	0
Total	$25,000	$406,000	$1,373,000	$2,934,000	$113,000	$136,000

Public Damages

Public damages were assessed from actual experience in the 1965 and 1969 floods, discussions and interviews with public officials, and consultation of the city's flood preparedness plan. The latter was written in 1980 as an appendix to the Chaska Comprehensive Stormwater Management Plan and outlines the emergency measures necessary to prepare for flooding from the Minnesota River. About one-half of public damage is for flood emergency costs. The other half is physical damage to public structures and facilities. Below is a listing of data on public damages. Average annual public damages for present conditions total $246,000.

Public Damages at Chaska
Without Emergency Levee Credit

Reach	Flood Event 20-percent	10-percent	1-percent	0.2-percent	Existing Average Annual Damages	Existing and Future Average Annual Damages
1	$ 42,000	$227,000	$3,747,000	$7,789,000	$138,000	$146,000
2	8,000	17,000	40,000	51,000	5,000	7,000
3	6,000	18,000	180,000	337,000	7,000	8,000
4	128,000	410,000	646,000	727,000	96,000	116,000
5	0	0	6,000	11,000	0	0
Total	$184,000	$672,000	$4,619,000	$8,915,000	$246,000	$277,000

Summary

Present conditions average annual damages total $1,806,000 at Chaska. The following tables present summaries of damage data by reach and by damage category.

Summary of Damages at Chaska by Reach
Without the Emergency Levee in Place

Flood Event

Reach	20-percent	10-percent	1-percent	0.2-percent	Average Annual Damage	Existing and Future Average Annual Damage	Percentage of Total Average Annual Damage
1	$ 242,000	$1,685,000	$11,195,000	$21,695,000	$ 617,000	$ 752,000	29
2	660,000	1,738,000	2,276,000	2,643,000	360,000	722,000	27
3	61,000	169,000	3,282,000	4,887,000	107,000	205,000	8
4	553,000	1,945,000	2,748,000	3,025,000	714,000	936,000	36
5	0	23,000	145,000	241,000	8,000	12,000	---
Total	$1,516,000	$5,560,000	$19,646,000	$32,491,000	$1,806,000	$2,627,000	100

The emergency levee is given credit for protection to the 15-percent flood. However the levee also causes damages from the ponding of East Creek and Chaska Creek floods. The following table summarizes damages in Chaska while giving credit to the emergency levee.

Summary of the Damages at Chaska by Reach
With the Levee in Place

Reach	20-percent	Existing Average Annual Damages	Existing and Future Average Annual Damages
1	159,000	602,000	734,000
2	660,000	360,000	722,000
3	94,000	118,000	226,000
4	553,000	714,000	936,000
5	0	8,000	12,000
Total	1,466,000	1,802,000	2,630,000

FLOOD DAMAGE REDUCTION BENEFITS

Flood damage reduction benefits are the difference between damages without and with the project. The proposed measures have equivalent annual benefits of $2,264,000 without giving credit to the emergency levee and $2,267,000 with credit to the emergency levee. Benefit summaries by reach and by category are presented below for the base year, year 2040, and equivalent annual conditions. Also shown is a table listing the number and value of structures and flood depths for the with-project floodplain.

Flood Damage Reduction Benefits at Chaska by Reach
Without the Emergency Levee in Place

Average Annual Benefits

Reach	Base Year (1990)	Future Conditions (2040)	Equivalent Annual Benefits	Percentage of Total Equivalent Annual Benefits
1	$ 511,000	$ 697,000	$ 598,000	27
2	451,000	1,388,000	720,000	32
3	115,000	480,000	198,000	9
4	684,000	1,046,000	742,000	32
5	4,000	12,000	6,000	--
Total	$1,765,000	$3,623,000	$2,264,000	100

Flood Damage Reduction Benefits at Chaska by Reach
With the Emergency Levee in Place

Reach	Base Year 1990	Future Conditions 2040	Equivalent Annual Benefits
1	498,000	681,000	580,000
2	451,000	1,388,000	720,000
3	122,000	530,000	219,000
4	684,000	1,036,000	742,000
5	4,000	12,000	6,000
Total	1,729,000	3,627,000	2,267,000

Residual Flooding in Chaska Floodplain

Number of Structures

Floodplain	Residential	Commercial	Public	Total Structure Value (000)	Maximum Flood Depths 0.1-percent Frequency Event (feet)
Minnesota River	0	0	0	$0	0
Chaska					
Within Minnesota River floodplain	0	0	0	0	0
Outside of Minnesota River floodplain	0	0	0	0	0
Total	0	0	0	0	---
East Creek					
Within Minnesota River floodplain	10	0	0	0.6	2
Outside of Minnesota River floodplain	25	6	0	4.3	3
Total	35	6	0	4.9	---
Grand Total	35	6	0	4.9	---
Percentage reduction from existing conditions	93	75	100	85	---

RELATED BENEFITS

Saving of Flood Insurance Administrative Costs

Two hundred forty-seven structures in Chaska are currently enrolled in the Flood Insurance Program. If the project were in place, an estimated 205 of these policies (83 percent) would be cancelled. (The total number of floodplain structures is reduced 83 percent with the project.) Savings would result to the nation because resources used for administrative work would become available for other work.

A January 1982 memorandum from the Federal Emergency Management Administration listed administrative costs at an average of $42 per policy. Therefore, average annual flood insurance administrative costs savings are $8,600 (205 x $42) with the proposed project.

Land Development Benefits

In cases where a project alters the cost or pattern of new development in the floodplain, the project's effect on land income can be a project benefit. Evaluation of these benefits is generally accomplished by using land market value data.

However, the Chaska floodplain is fully developed, and the project is not expected to affect future use of the floodplain. Therefore, the project does not have location, intensification, or flood proofing cost savings benefits.

RECREATION BENEFITS

The average annual benefits from recreation features of the project are $28,000. This number was derived from an update and a change in interest rates.

BENEFIT - COST ANALYSIS

Summary of Benefits

National economic development benefits attributable to the proposed project include flood damage reduction, saving of flood insurance administrative costs, and recreation. Total equivalent annual benefits are $2,301,000, as summarized below.

Benefit Summary, Chaska, Minnesota
(October 1983 Prices; 8-1/8 per t Discount Rate)

Benefit	Without Levee Equivalent Annual Amount	With Levee Equivalent Annual Amount
Flood damage reduction	$2,264,000	$2,267,000
Saving of flood insurance administrative costs	9,000	9,000
Recreation	28,000	28,000
Total	$2,301,000	$2,304,000

Annual Costs

Annual costs for the project are the sum of amortized first costs and annual operations and maintenance costs. First costs include no interest during construction because each separable feature of the project will be completed in one construction season.

Calculations below show annual costs to be $2,076,000

Calculation of Annual Charges for the Proposed Project, Chaska, Minnesota (October 1983 Prices: 8 1/8 percent Discount Rate)

Item	Amount
Federal and Non-Federal First Cost	$23,596,000
Interest during construction	1,415,000
Total investment cost	$25,011,000
Interest and amortization ($17,591,000 x 0.08128)	2,033,000
Flood control components	40,000
Recreation	3,000
Total Annual Charges	2,076,000

Relationship of Benefits to Costs

The project has net annual benefits of $225,000 a benefit-cost ratio of 1.11.

Benefit-Cost Analysis, Chaska, Minnesota
(October 1983 Prices; 8 1/8-percent Discount Rate)

Item	Amount
Equivalent annual benefits	$2,301,000
Annual costs	2,076,000
Net benefits	$ 225,000
Benefit-cost ratio	1.11

EXECUTIVE ORDER 11988

Executive Order 11988 states that Federal agencies shall avoid to the extent possible the long- and short-term adverse impacts associated with occupancy and modifications of floodplains and to avoid direct and indirect support of floodplain development wherever there is a practicable alternative. The order requires Federal agencies to provide leadership and take action to:

- Avoid the base floodplain unless it is the only practicable alternative. Practicable involves consideration of pertinent factors such a environment, cost, or technology
- Minimize the impact of floods on human safety, health, and welfare
- Restore and preserve the natural and beneficial floodplain values
- Avoid action in the floodplain that encourages, allows, serves, or otherwise facilitates additional floodplain development

The proposed project at Chaska is in compliance with the Executive Order. It significantly reduces flood risk to existing development with measures that address the dual objectives of national economic development and environmental quality. Proposed measures represent the only practicable alternative. Appropriate consideration has been given in the planning process to non-structural measures. Finally, since Chaska floodplain development is already considered complete, the project does not encourage additional development. Growth in Chaska will take place in the East Creek watershed in areas above the bluff line of the Minnesota River valley, but no changes in floodplain development is expected, with or without the proposed project.

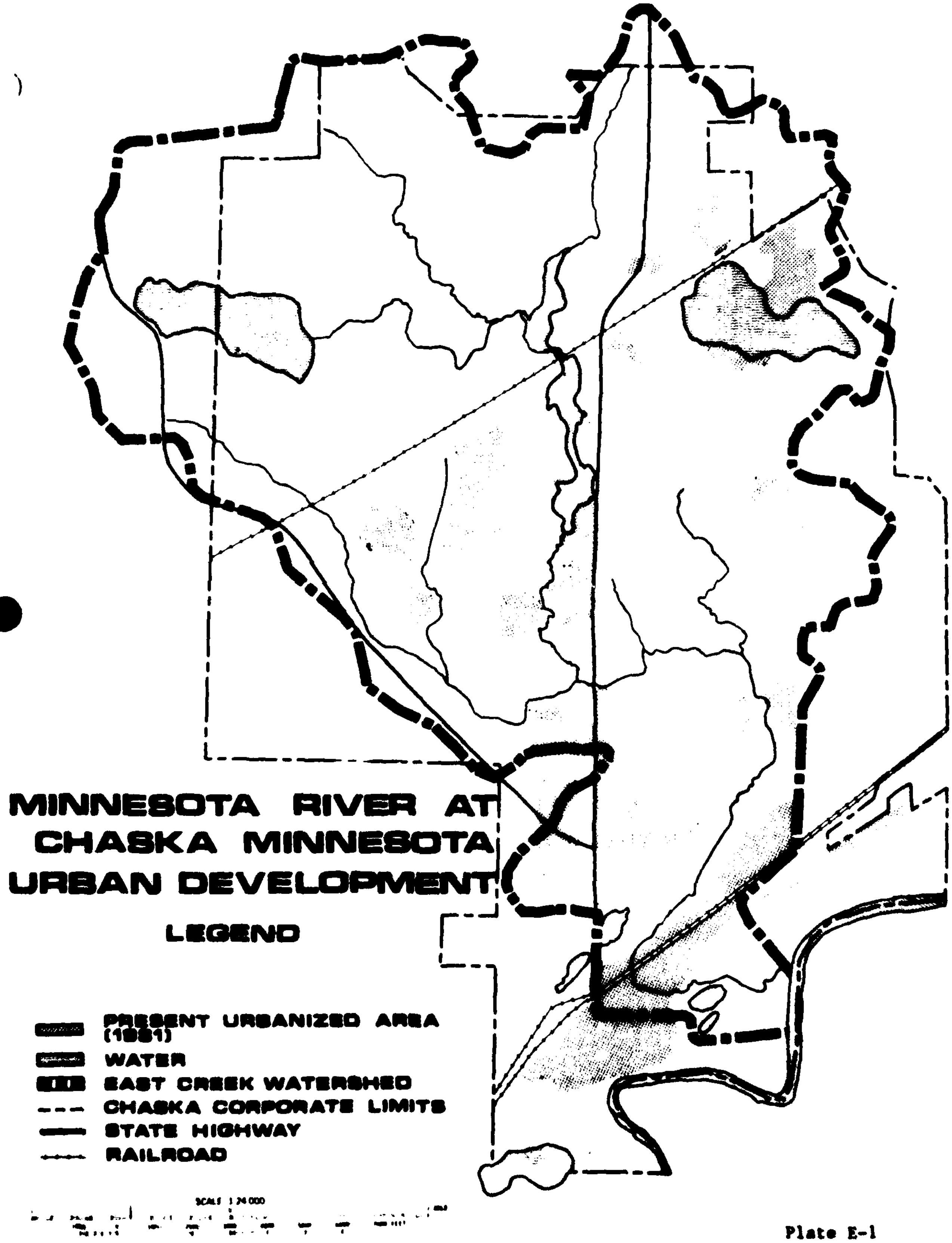

MINNESOTA RIVER AT
CHASKA MINNESOTA
URBAN DEVELOPMENT
LEGEND
PRESENT URBANIZED AREA
WATER
EAST CREEK WATERSHED
CHASKA CORPORATE LIMITS
STATE HIGHWAY
RAILROAD
SCALE 1:24 000

Plate E-1

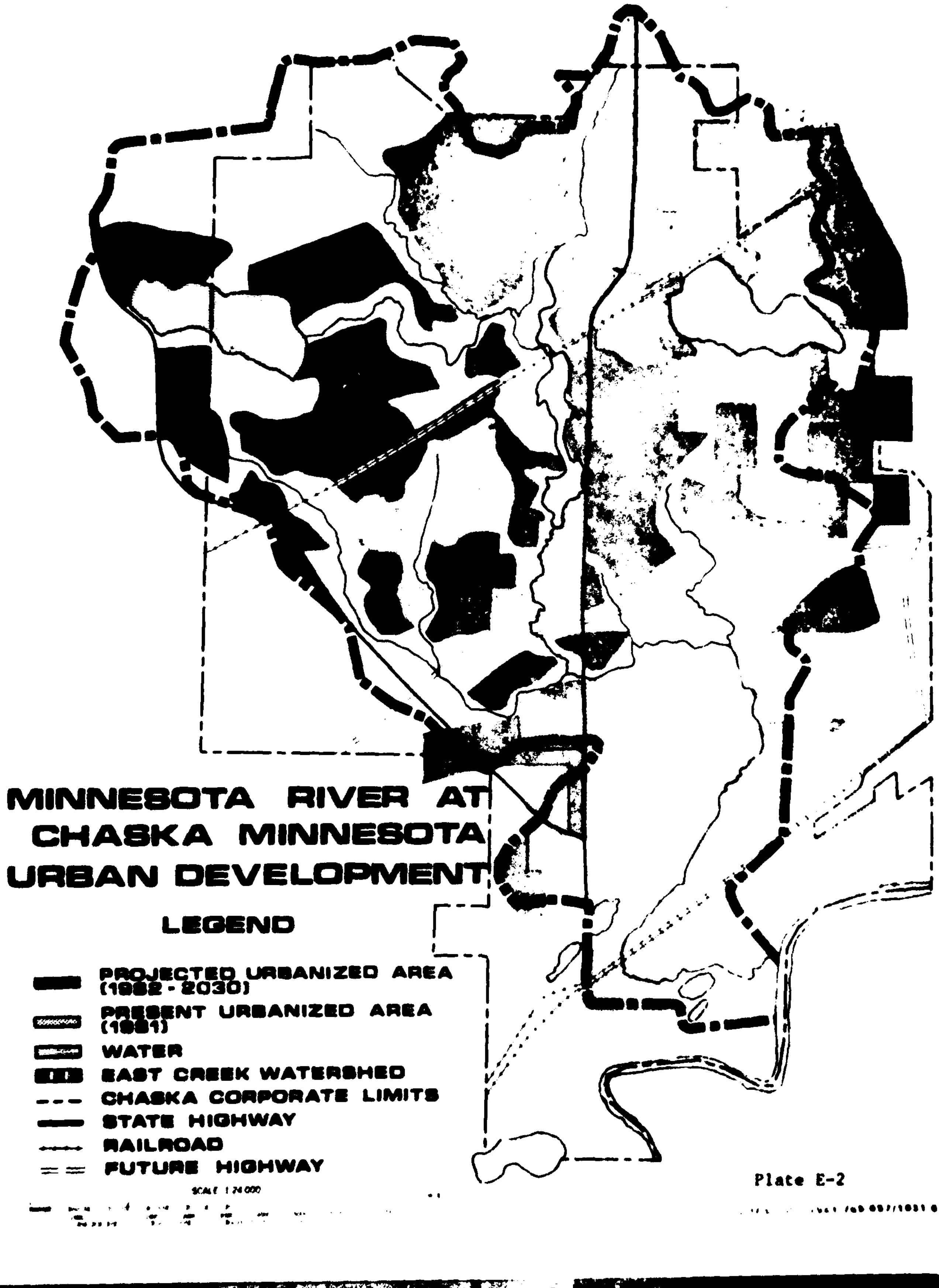
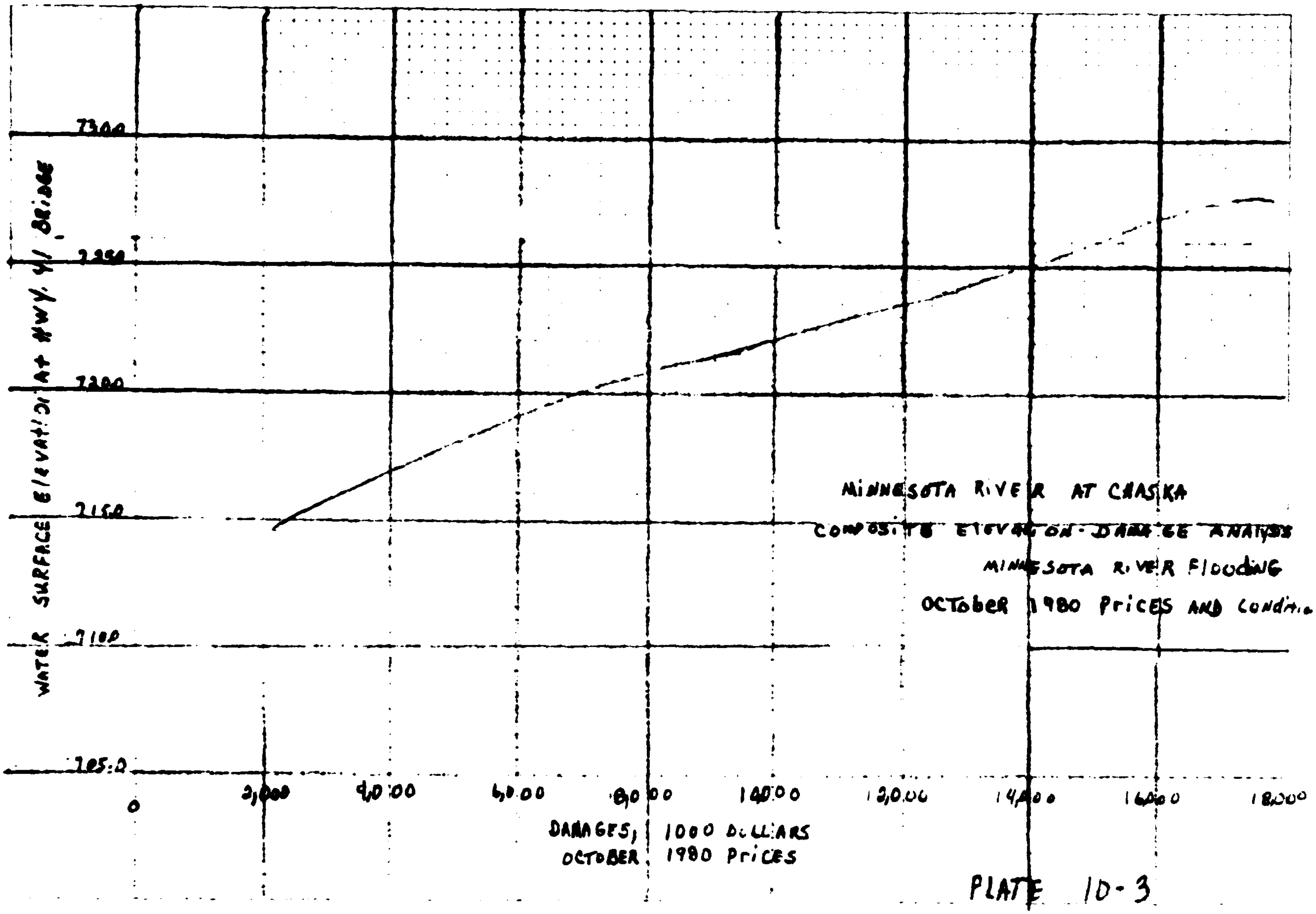

MINNESOTA RIVER AT
CHASKA MINNESOTA
URBAN DEVELOPMENT
LEGEND
PROJECTED URBANIZED AREA (1982 - 2030)
PRESENT URBANIZED AREA (1981)
WATER
EAST CREEK WATERSHED
CHASKA CORPORATE LIMITS
STATE HIGHWAY
RAILROAD
FUTURE HIGHWAY

Plate E-2



MINNESOTA RIVER AT CHASKA
COMPOSITE ELEVATION-DAMAGE ANALYSIS
MINNESOTA RIVER FLOODING
OCTOBER 1980 PRICES AND CONDITIONS
WATER SURFACE ELEVATION AT HWY. 41 BRIDGE
730.0
725.0
720.0
715.0
710.0
705.0
0
2,000
4,000
6,000
8,000
10,000
12,000
14,000
16,000
18,000
DAMAGES, 1000 DOLLARS
OCTOBER 1980 PRICES
PLATE 10-3

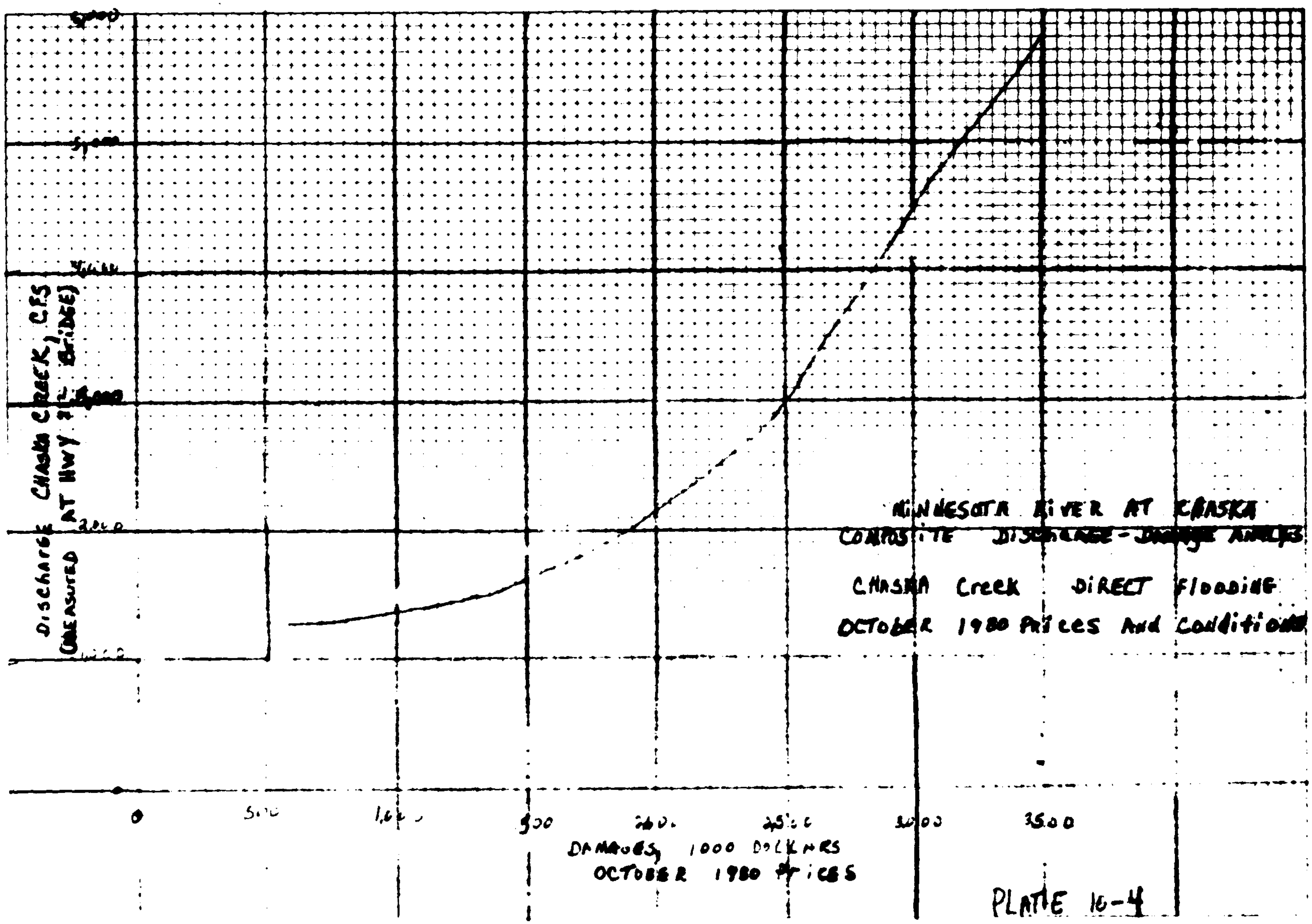

DISCHARGE CHASKA CREEK, CFS
(MEASURED AT HWY 212 BRIDGE)
MINNESOTA RIVER AT CHASKA
COMPOSITE DISCHARGE-DAMAGE ANALYSIS
CHASKA Creek DIRECT FLOODING
OCTOBER 1980 PRICES And Conditions
DAMAGES, 1000 DOLLARS
OCTOBER 1980 PRICES
0
3500
PLATE 16-4

Plate E-4

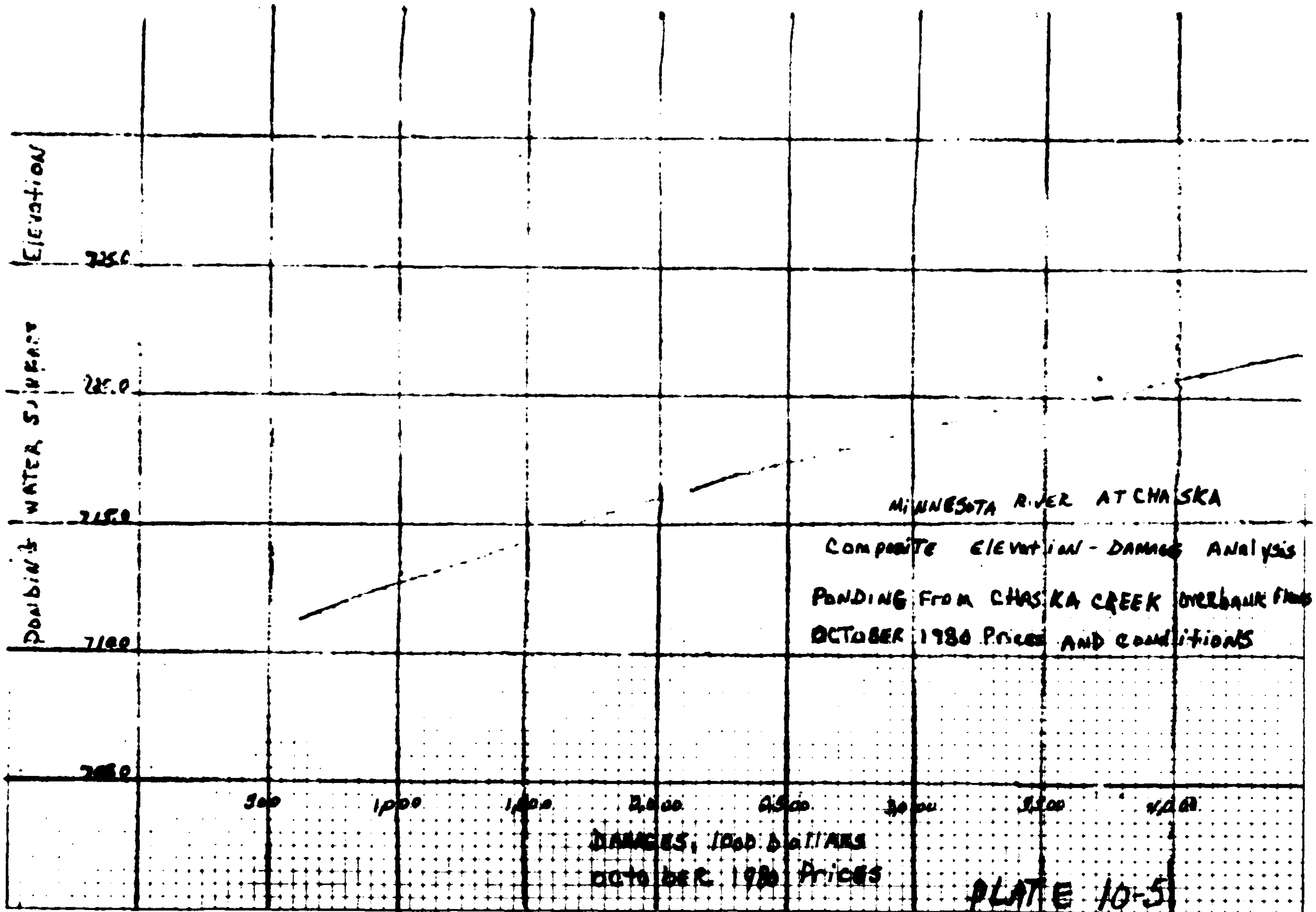
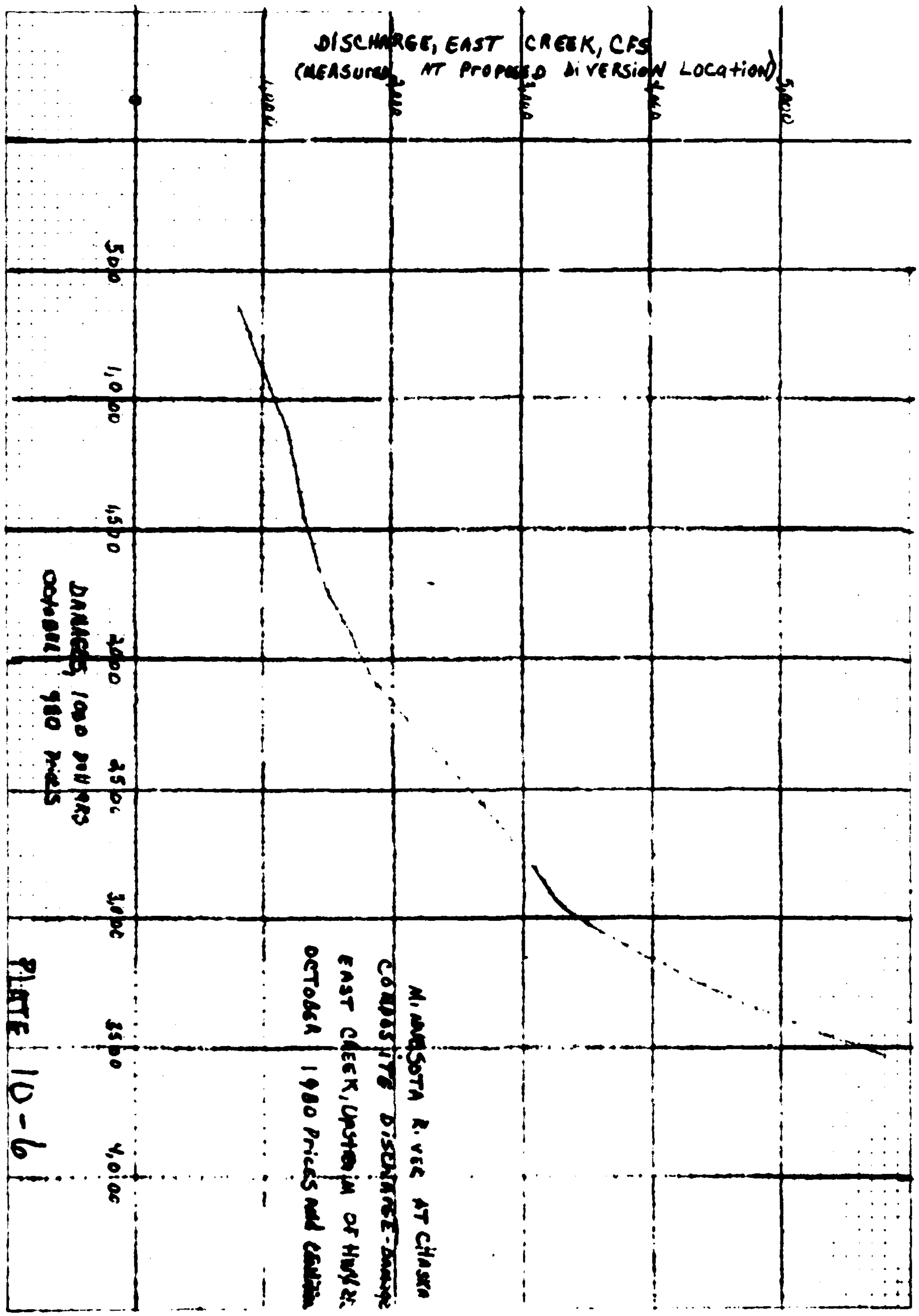
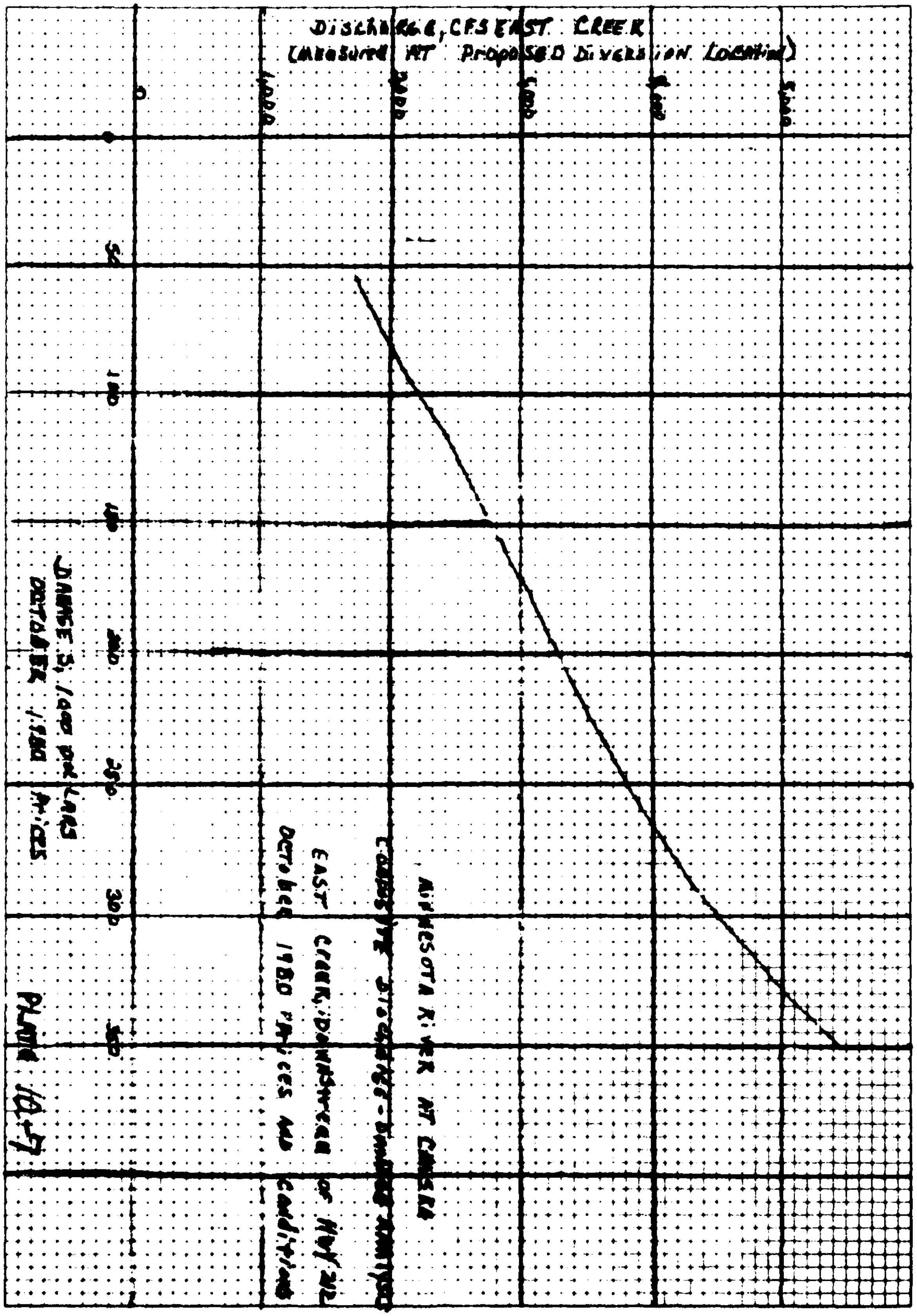

MINNESOTA RIVER AT CHASKA
Composite Elevation - Damage Analysis
PONDING From CHASKA CREEK Overbank Flow
OCTOBER 1980 Prices AND conditions
PONDING WATER SURFACE ELEVATION
DAMAGES, 1000 DOLLARS
OCTOBER 1980 Prices
500
1,000
1,500
2,000
2,500
3,000
3,500
4,000
PLATE 10-5

Plate E-5


DISCHARGE, EAST CREEK, CFS
(MEASURED AT PROPOSED DIVERSION LOCATION)
500
1,000
1,500
2,000
2,500
3,000
3,500
4,000
DAMAGES, 1000 DOLLARS
OCTOBER 1980 PRICES
MINNESOTA RIVER AT CHASKA
COMPOSITE DISCHARGE-DAMAGE
EAST CREEK, UPSTREAM OF HWY.
OCTOBER 1980 PRICES and CONDITIONS
PLATE 10-6


DISCHARGE, CFS EAST CREEK
(MEASURED AT PROPOSED DIVERSION LOCATION)
0
1,000
2,000
3,000
4,000
5,000
0
50
100
150
200
250
300
350
MINNESOTA RIVER AT CHASKA
EAST CREEK, DOWNSTREAM OF HWY 212
OCTOBER 1980 PRICES AND CONDITIONS
DAMAGE $, 1,000 DOLLARS
OCTOBER 1980 PRICES
PLATE 10-7

APPENDIX F

DETAILED ESTIMATE OF FIRST COST
(October 1983 price levels)

ITEM	UNIT	QUANTITY	UNIT COST	TOTAL ESTIMATED COST
FEDERAL FIRST COST				
Relocations				
Railroads				
Construct bridge	Job	Sum	180,000	180,000
Remove abandoned bridge	Job	Sum	12,000	12,000
Relocation Railroad of West CR			100,000	100,000
Relocation for East CR			50,000	50,000
Subtotal				342,000
Contingencies				68,000
TOTAL RAILROAD				410,000
TOTAL RELOCATION				410,000
Fish and Wildlife facilities (Chaska Lake moist soil unit with Chaska Lake control structure)				
Levee fill and compaction	CY	10,320	2.25	23,220
Seeding	Ac	3.7	1,000.00	3,700
Gravel	CY	310	11.00	3,410
Excavation	CY	370	3.00	1,110
Riprap	CY	6	23.00	138
Control structure 1	Job	Sum	--	6,600
Control structure 2	Job	Sum	--	6,600
Control structure 3	Job	Sum	--	7,900
Pumping pad	Job	Sum	--	1,500
Pumping facilities				49,500
Chaska Lake outlet structure	Job	Sum	--	12,000
Contingencies				17,322
TOTAL FISH AND WILDLIFE FACILITIES				133,000
Channels				
Chaska Creek Diversion				
Excavation	CY	138,000	1.85	255,300
Backfill	CY	54,000	1.00	54,000
Riprap	CY	3,400	24.00	81,600
Bedding	CY	1,700	14.00	23,800
Drop Structure Sta. 19+00	Job	Sum	120,000	120,000
Drop Structure Sta. 65+00	Job	Sum	420,000	420,000
35' Concrete Channel	LF	1760	715.00	1,258,400
37.5' Concrete Channel	LF	2693	740.00	1,992,820
Channel bedding	CY	13,000	8.00	104,000
Levee Fill	CY	300	1.00	300
Seeding & Mulching	Ac	2.2	1000.00	2,200
Subtotal				4,312,420
Contingencies				862,580
TOTAL CHASKA CREEK DIVERSION				5,175,000

DETAILED ESTIMATE OF FIRST COST
(October 1983 price levels)

ITEM	UNIT	QUANTITY	UNIT COST	TOTAL ESTIMATED COST
FEDERAL FIRST COST				
Hickory St. Drainage Channel				
Excavation	CY	5700	1.85	10,545
Backfill	CY	2,500	1.00	2,500
Side Inlet Structure	Job	Sum	21,000.00	21,000
Drop Structure	Job	Sum	38,000.00	38,000
Concrete Channel Tranqual Flow	LF	160	400.00	64,000
Concrete Channel Rapid Flow	LF	500	285.00	142,500
Seeding & Mulching	Ac	0.6	1000.00	600
Subtotal				279,145
Contingencies				41,855
TOTAL HICKORY ST. DRAINAGE				321,000
Chaska Creek Service Road				
Excavation	CY	5,600	2.00	11,200
Fill	CY	900	1.00	900
Gravel Surface	CY	1,700	2.00	20,400
Seeding & Mulching	Ac	2.2	1000	2,200
Subtotal				34,700
Contingencies				5,300
TOTAL CHASKA CREEK SERVICE ROAD				40,000
East Creek Diversion				
Levee Fill (off site)	CY	109,900	2.25	247,275
Excauation	CY	270,000	1.85	499,500
Backfill	CY	18,000	1.00	18,000
Fill	CY	22,000	1.00	22,000
Control Structure Sta. 5+00	Job	Sum	322,000	322,000
Stilling Basin Sta. 22+00	Job	Sum	350,000	350,000
16' x 16' Box Culvert	LF	1469	1700	2,497,300
Inlet Structure Sta. 38+35	Job	Sum	182,000	182,000
Catch Basin Sta. 36+88	Job	Sum	2,000	2,000
Transition Sta. 80+00 to 81+60	Job	Sum	309,000	309,000
50' Concrete Channel	LF	566	920	520,720
Transition Sta. 87+26 to 87+86	Job	Sum	90,000	90,000
Drop Structure Sta. 88+30	Job	Sum	365,000	365,000
48" CMP	LF	180	60.00	10,800
48" Gate Well w/sluice Gate	Job	Sum	30,000	30,000
24" CMP	LF	60	30.00	1,800
24" Flop Gate	Job	Sum	500	500
21" Riprap	CY	2,700	23.00	62,100
Bedding	CY	1,400	14.00	19,600
12" Riprap	CY	5,500	23.00	126,500
Bedding	CY	2,700	14.00	37,800
Seeding & Mulching	Ac	27	1000	27,000
Subtotal				5,740,895
Contingencies				1,148,105
TOTAL EAST CREEK DIVERSION				6,889,000
TOTAL CHANNELS				12,425,000

DETAILED ESTIMATE OF FIRST COST
(October 1983 price levels)

ITEM	UNIT	QUANTITY	UNIT COST	TOTAL ESTIMATED COST
FEDERAL FIRST COST				
Leeves				
Leeves Work				
Fill	CY	238,000	2.25	535,500
Excavation & Side Cast	CY	52,200	1.25	65,250
Excavation & Disposal	CY	26,000	2.25	58,500
Cut Existing Levees	CY	11,300	1.25	14,125
Fill Stability Berms (Reshaping)	CY	12,000	2.00	24,000
Semipervious Fill	CY	17,200	2.25	38,000
Inspection Trench	LF	6,780	20.00	135,600
Seeding & Mulching	Ac	39.3	1000.00	29,200
Landscaping	Job	Sum	95,000	95,000
Remove existing culverts	Job	Sum	20,000	20,000
Subtotal				1,025,875
Contingencies				154,125
TOTAL LEVEE WORK				1,180,000
Closures				
No. 2 (sandbag closure on Hwy 41)	Job	Sum	—	4,000
No. 3 (sandbag closure on First St.)	Job	Sum	—	4,000
No. 4 (Seepage barrier Mpls. St. Louis RR)	Job	Sum	—	5,000
Contingencies	Job	Sum	—	2,000
TOTAL CLOSURES				15,000
Drainage Facilities				
Reinforced Concrete Pipe:				
12" I	LF	520	28.00	14,560
33" I	LF	425	65.00	27,625
48" I	LF	345	95.00	32,775
60" IV	LF	900	160.00	144,000
60" 3551	LF	170	175.00	29,750
72" IV	LF	340	185.00	62,900
78" IV	LF	750	200.00	150,000
84" III	LF	1170	215.00	251,550
84" 6037	LF	170	250.00	42,500
90" 6892	LF	230	270.00	62,100
108" 6190	LF	340	325.00	110,500
Gatewell 60"	EA	2	21,000	42,000
Gatewell 84"	EA	1	60,000	60,000
Gatewell 90"	EA	1	65,000	65,000
Gatewell Double 108	EA	1	122,000	122,000
Sluice Gate				
60"	EA	1	15,000	15,000
84"	EA	1	29,000	29,000
90"	EA	1	34,000	34,000
103"	EA	2	46,000	92,000
Manhole w/grated inlet	EA	1	5,000	5,000
Inlet Structure Outlet A	Job	Sum	30,000	30,000
Inlet Standard	EA	12	2,000	2,000
Subtotal				1,446,260
Contingencies				216,740
TOTAL DRAINAGE FACILITIES				1,663,000

DETAILED ESTIMATE OF FIRST COST
(October 1983 price levels)

ITEM	UNIT	QUANTITY	UNIT COST	TOTAL ESTIMATED COST
FEDERAL FIRST COST				
RELIEF WELL SYSTEM				
Relief Wells	EA	30	6,000	180,000
Check Valves	EA	8	750	6,000
Subtotal				186,000
Contingencies				37,000
TOTAL				223,000
TOTAL LEVEE UP GRADE				3,081,000
Pumping Plants				
Pump Station (21,700 GPM)	Job	Sum	400,000	400,000
Subtotal				400,000
Contingencies				80,000
TOTAL PUMPING PLANTS				480,000
TOTAL CONSTRUCTION COST				16,529,000
TOTAL ENGINEERING AND DESIGN				1,983,000
TOTAL SUPERVISION AND ADMINISTRATION				1,156,000
TOTAL FEDERAL RECREATION FACILITY COST				42,000
TOTAL FEDERAL FIRST COST				19,710,000

DETAILED ESTIMATE OF FIRST COST
(October 1983 price levels)

ITEM	UNIT	QUANTITY	UNIT COST	TOTAL ESTIMATED COST
NON- FEDERAL FIRST COST				
Lands and Damages				
Perpetual easements	Job	Sum		600,000
Temporary easements	Job	Sum		140,000
Improvements	Job	Sum		500,000
Contingency				250,000
Ph 91-646 Relocation Payments	Job	Sum		70,000
Administrative				140,000
TOTAL LANDS AND DAMAGES				1,700,000
Relocations				
Bridge Removal				
Road Raise Hwy 10	LF	180	40.00	7,200
Hickory St. Access Road	LF	275	50.00	13,750
Remove Culvert on Hwy 41	Job	Sum	360,000	360,000
Remove Brandon Blvd. Bridge	Job	Sum	30,000	30,000
Remove Box Culvert on Englar Blvd.	Job	Sum	10,000	10,000
Remove Hillside Dr. Bridge	Job	Sum	15,000	15,000
Remove First Street Bridge	Job	Sum	15,000	15,000
Subtotal				450,950
Contingencies				90,050
TOTAL BRIDGE REMOVAL				541,000
Bridge Modifications				
Construct Hwy 41 Bridge	Job	Sum	370,000	370,000
Construct Brandon Blvd. Bridge	Job	Sum	110,000	110,000
Construct Englar Blvd. Bridge	Job	Sum	220,000	220,000
Construct Hillside Dr. Bridge	Job	Sum	100,000	100,000
Construct Hickory St. Bridge	Job	Sum	115,000	115,000
Construct First Street Bridge	Job	Sum	120,000	120,000
Subtotal				1,035,000
Contingencies				207,000
TOTAL BRIDGE MODIFICATIONS				1,242,000

DETAILED ESTIMATE OF FIRST COST
(October 1983 price levels)

ITEM	UNIT	QUANTITY	UNIT COST	TOTAL ESTIMATED COST
NON- FEDERAL FIRST COST				
Utilities				
East Creek Waterline Relocations				
6" DI	LF	90	19.00	1,710
8" DI	LF	1210	25.00	30,960
10" DI	LF	100	32.00	3,200
12" DI	LF	500	38.00	1,900
Relocated hydrant	Ea	1	2000	2,000
Sanitary Sewer Relocation				
8" UCP	LF	990	13.00	12,870
10" UCP	LF	90	17.00	1,530
21" RCP	LF	1610	56.00	90,160
West Creek				
Sanitary Sewer Siption	Job	Sum	16,000	16,000
Construct 6-inch water main bridge crossing	LF	100	80.00	8,000
Relocate utility poles	Job	Sum	30,000	30,000
Levees				
Install 8-inch UCP Sewer	LF	2,200	13.00	28,600
Install manholes	Ea	5	3,000	15,000
Install 8-inch CIP forceman	LF	1,400	25.00	35,000
Install 8-inch gate valve	Ea	1	820.00	820
Relocate hydrant	Ea	1	2,000	2,000
Relocate utility lines	Job	Sum	20,000	20,000
Subtotal				299,040
Contingencies				59,960
TOTAL UTILITIES				359,000
TOTAL RELOCATIONS				2,142,000
NON-FEDERAL SHARE OF RECREATIONS COSTS				42,000
TOTAL NON-FEDERAL FIRST COSTS				3,884,000
TOTAL FIRST COST				
FEDERAL FIRST COST				19,710,000
NON-FEDERAL FIRST COST				3,884,000
TOTAL FIRST COSTS				23,594,000

TABLE OF CONTENTS

APPENDIX G
RECREATION RESOURCES DEVELOPMENT AND AESTHETICS

INTRODUCTION

RECREATION

Authority

1. The authority to study recreation resources at Corps of Engineers projects is contained in the Federal Water Project Recreation Act of 1965 (P.L. 89-72), as amended. This act established recreation development at Federal water resource projects as a full project purpose to be addressed in all phases of study. Section 2(a) specifies that benefits for recreation should be included in the economics of a contemplated project, provided that non-Federal public entities agree to participate in the recreation development (provide a Letter of Intent).

2. Underlying the authority to consider recreation as a full project purpose is Section 4 of the Flood Control Act of 1944, as amended. This act authorizes the Corps of Engineers to construct public recreation facilities at water resource development projects.

3. Special recreation facilities, such as trails, are covered under engineering guidelines described in Engineering Regulation 1165-2-1. The special facility section of this regulation states that, "Project planning shall consider the incorporation of trails for nature study, hiking, self-propelled bicycle, horseback riding, snowshoe, cross-country ski, and access by fishermen and hunters. When practical, such trails are located to tie into existing hiking trails and metropolitan bicycle trails."

Purpose of the Study

4. The present study is to review the 1973 feasibility report for flood control at Chaska, Minnesota, and apply current planning criteria and study area information. The reason for this review is to determine if any changes have occurred since the congressional review in 1976 which would affect the authorized plan.

Scope of the Study

5. This study is a reanalysis of those factors which can be expected to affect existing and future participation rates for trail-associated activities. Factors to be included in this study will include but not be limited to:

a. Changes in demographic data.

b. Development of competing facilities within the project influence area.

c. National and regional recreation participation trends.

In addition, the study will discuss whether additional development of recreation facilities is appropriate and economically justified.

Background

6. In 1973, a feasibility report on flood control at Chaska, Minnesota, concluded that a combined levee trail system was a desirable and economically justified development. To comply with the requirements for local cooperation in the development of recreation facilities, the city of Chaska provided the Corps with a resolution documenting its intent to participate in the cost-sharing agreements as defined in the 1973 feasibility report. The U.S. Department of the Interior - Bureau of Outdoor Recreation (now the Heritage Conservation and Recreation Service) and the county of Carver supported the combined levee trail development. The Bureau of Outdoor Recreation especially noted that linkage with the Minnesota River Valley Trail, which will extend from Fort Snelling to Le Sueur, was highly desirable. In 1976, Congress authorized the recommended plan for construction.

Basic Assumptions

7. It is assumed in this report that the climate, topography, geology, accessibility, biologic, and ecologic features and resources in the area have remained unchanged for the most part. However, local attractions have changed since the bankruptcy of the Jonathan Development Corporation and the subsequent scaling down of the New Town Development by the Department of Housing and Urban Development. The impacts of this change will be considered in greater detail later in the report. Flood control project data is expected to remain substantially unchanged.

RECREATION MARKET AREA

RECREATIONAL ZONE OF INFLUENCE

8. The area surrounding the project that can be expected to contribute 80 percent of estimated visitation is called the zone of influence. In the 1973 feasibility report, it was assumed that demand would essentially come only from the Chaska-Jonathan area. Some additional visitation is expected as a result of the proximity of the Minnesota Valley State Trail, which is planned to connect with the proposed flood control levee.

9. At this time, there is no reason to believe that the previous demand assumption is inaccurate. There are numerous existing and proposed regional parks and park reserves well distributed within the metro region that offer residents an assortment of specialized recreation activities and facilities. There is nothing unique about the project site that would induce any significant displacement of regional demand to Chaska. No attempt has been made to determine what portion of the Minnesota Valley State Trail use should be claimed in the benefit analysis.

10. Proposed pedestrian greenways along the East Creek will serve to connect the proposed trail with the following recreation elements within the influence area that now function separately (see plate 3):

a. Hennepin County Park Reserve at Carver, Minnesota.

b. University of Minnesota Arboretum.

c. Jonathan Area.

d. Minnesota River Valley Trail and National Wildlife Refuge.

e. Twin Cities Metro Council Regional Recreation Open Space System Plan.

f. Winkel Memorial Park and the Chaska Athletic Field.

In this regard, the levee trail system takes on a regional as well as local recreation significance.

SOCIOECONOMIC CHARACTERISTICS OF THE MARKET AREA

11. Population projections within the Chaska-Jonathan zone of influence have changed since the 1973 feasibility analysis because of the bankruptcy of the Jonathan Development Corporation. Current and projected populations within the zone of influence are shown in table 1.

Table 1

Year	Population*
1980	8,400
1985	12,000
1990	15,500
1995	19,000
2000	22,500
2030	40,500

*Population estimates up to the year 2000 were obtained from the Twin Cities Metropolitan Council. An extrapolated estimate was made by the St. Paul District Economic Section for the year 2030.

LEISURE TIME ANALYSIS

12. The Third Nationwide Outdoor Recreation Plan published by the U.S. Department of the Interior - Heritage Conservation and Recreation Service (HCRS) in 1979 provides a good indication of expected trends in participation rates. Key factors which are affecting current activity patterns and which should be considered in all local recreation project analyses are:

a. Changes in the population's age structure resulting from the "baby boom" and subsequent "baby bust."

b. Changes in traditional male-female roles and the consequent impact upon the recreation market.

c. The continued rise in real income and the resulting increase in the proportion available for recreation.

d. The effects of increased leisure time available to the labor force as a result of congressionally mandated Monday holidays and policies such as flex-time.

13. In general, it is reasonable to assume that recreation participation rates will continue to grow in the foreseeable future. It is also important to consider the impacts of energy constraints in our analysis. Recent studies indicate that people are traveling shorter distances, but spending longer periods of time at their destination. Thus, recreation facilities closer to home are currently experiencing heavier use than in the past. However, more time is needed to observe energy impacts on participation rates before trend conclusions can be made.

REGIONAL RECREATION DEMAND/NEEDS ANALYSIS

14. The 1979 Minnesota State Comprehensive Outdoor Recreation Plan (SCORP) has identified a number of recreation activities that should be expanded within the seven-county metro region, which includes the Chaska project area. The planning staff recommended that recreation providers concentrate on developing opportunities for cross-country skiing, bicycling, playing tennis, fishing, boating, golf, swimming, and hiking.

15. Their surveys of more than 20,000 Minnesota households in the State indicated that cross-country skiing was the most requested winter activity in the metro region. Hunting, snowmobiling, and ice skating followed in popularity. Bicycling was a heavily requested summer recreation activity; in fact, it was the only activity requested for expansion by more than 20 percent of the people polled. Camping, tennis, and fishing opportunities were also requested. The activities

listed in the SCORP which were requested by people in the metro region are shown on table 2.

Table 2

Winter Activities	Summer Activities	
Cross-country skiing	Bicycling	Horseback riding
Hunting	Camping	Backpacking
Snowmobiling	Tennis	Walking
Ice skating	Fishing	Baseball/softball
Miscellaneous skiing	Swimming	Jogging
Downhill skiing	Hiking	Archery
Target shooting	Golfing	Soccer
Ice fishing	Picnicking	Historic site visit
Trapping	Boating	RV uses
Sledding	Park facilities	Water skiing
Snow tubing	Canoeing	Bird watching
Snowshoeing	Trail biking	

16. Of special note within the metro region is the development of the Minnesota Valley National Wildlife Refuge and Recreation Area. The Wildlife Refuge is made up of numerous land units located along the Minnesota River from Fort Snelling in Minneapolis upriver to Le Sueur. These land units will become a part of the National Wildlife Refuge System and will be owned and managed by the U.S. Fish and Wildlife Service (FWS). Besides its wildlife management benefits, the refuge will provide compatible opportunities for observation, recreation, and environmental education. Connecting the various land units will be the Minnesota Valley Trail. The trail will provide recreationists an opportunity to travel nearly 75 miles along the Minnesota River, paralleling the historic trails of native Americans and early white settlers. Coordination with the State planning team responsible for the design and route selection has revealed a need and desirability to connect the Valley Trail with the proposed Corps levee at Chaska, Minnesota.

17. Nature interpretation centers within the seven-county metro region receive heavy use throughout the year. In 1978, the Carver Park Reserve had an attendance of approximately 45,000 persons. The University of Minnesota arboretum has well over 100,000 in attendance. The proposed pedestrian greenways in Jonathan and Chaska will provide a means to link these two areas (see plate 3).

18. It appears that the development of trail-related facilities in conjunction with the proposed levee, as proposed in the 1973 feasibility report, still has the greatest merit. The levee trail system would allow recreationists access to the Minnesota River Valley Trail System, giving the area regional as well as local significance.

At present, there are limited opportunities for trail-related recreation activities within the immediate Chaska-Jonathan area.

DETERMINATION OF OUTDOOR RECREATIONAL ATTENDANCE

PER CAPITA PARTICIPATION RATES

19. The 1973 feasibility report identified six activities that were expected to constitute the majority of use at the project. Per capita participation rates were then taken from the West North Central Participation Rates, Bureau of Outdoor Recreation, 1969. However, the recently prepared Minnesota SCORP provides us with new participation data that have been incorporated into a new calculation of participation rates.

20. Unlike the 1973 report, only two predominant activities were carried into the 1982 limited reevaluation report recreation benefit calculations: recreation bicycling and nature walks. There are numerous additional trail-related activities (e.g., cross-country skiing, snowmobiling, sledding) that are also expected to occur. However, none of these activities will benefit substantially from the construction of an asphalt trail on top of the levee.

21. Participation rates for recreation bicycling and nature walks were obtained by comparing estimated and projected activity occasions originating in the metro region (1979 SCORP) against population data (Metro Council to year 2000 - extrapolated to 2030) as shown in tables 3 and 4.

Table 3

Recreation Bicycling

Year	Activity Occasions	Population	Participation[1] Rate
1978	23,421,808	1,792,781	13.06
1980	23,048,440	2,027,700	11.37
1985	22,886,541	2,121,500	10.79
1990	24,269,524	2,222,500	10.92
1995	25,194,655	2,300,500	10.95

(1)Obtained by dividing population into activity occasions.

Table 4

Nature Walks[2]

Year	Activity Occasions	Population	Participation Rate[1]
1978	1,455,388	1,792,781	.81
1980	1,492,651	2,027,700	.74
1985	1,572,002	2,121,500	.74
1990	1,704,915	2,222,500	.77
1995	1,818,440	2,300,500	.79

(1)Obtained by dividing population into activity occasions.
(2)Listed as birdwatching/nature study in the Minnesota SCORP.

22. It is assumed that these participation rates based upon the 1979 Minnesota SCORP reflect the existing and future demand for expected trail use more accurately than the participation rates used in the 1973 feasibility report.

ESTIMATED ATTENDANCE AT PROJECT

23. Tables 5 and 6 use the metro region participation rates previously determined to calculate the total annual activity occasions within the zone of influence (Chaska-Jonathan).

Table 5

Recreation Bicycling

Year	Population[1]	Participation Rates[2]	Activity Occasions[3]
1980	8,400	11.37	95,508
1985	12,000	10.79	129,480
1990	15,500	10.92	169,260
1995	19,000	10.95	208,050
2000	22,500	11.42[4]	256,950
2030	40,500	11.42[4]	462,510

(1)Metro Council to year 2000 (extrapolated to 2030)
(2)Calculated from Minnesota SCORP, 1979
(3)Activity occasions - participation rate X population
(4)Average participation rate calculated from Minnesota SCORP, 1979

24. Not all projected activity occasions within the zone of influence can be attributed to the project because not all of them would occur on the levee. Therefore, an adjustment was made in table 6. The "percentage of use" column reflects the percentage of the total activity occasions that could be expected to occur on the levee. Expected annual activity occasions for the project are then divided by 2.0 activities per day to convert to recreation days, which can be assigned a day-use value for calculation of benefits.

Table 6

Activity	Percentage of Use(1)	Adjusted Activity Occasions (With Project) 1980	1985	1990	1995	2000	2030
Recreation Bicycling	10	9,551	12,948	16,926	20,805	25,695	46,251
Nature Walks	25	4,662	6,660	8,951	11,257	12,994	23,389
Total		14,213	19,608	25,877	32,062	38,689	69,640
Recreation Days(2)		7,106	9,804	12,938	16,031	19,344	34,820

(1)Based upon Chaska feasibility report, Corps of Engineers, August 1973.
(2)Recreation days = activity occasions/2.0 activities per day.

25. Calculation of benefits must also take into account those activity occasions already occurring without the proposed project. The existing levee, although unimproved, is assumed to be having some use. The percentage of use column in table 8 is an estimate of this current use.

Table 7

Activity	Percentage of Use(1)	Adjusted Activity Occasions (Without Proj) 1980	1985	1990	1995	2000	2030
Recreation Bicycling	0	0	0	0	0	0	0
Nature Walk	10	622	888	1,193	1,501	1,732	3,118
Total		622	888	1,193	1,501	1,732	3,118
Recreation Days		311	444	596	750	866	1,559

(1)Based upon Chaska feasibility report, Corps of Engineers, August 1973.

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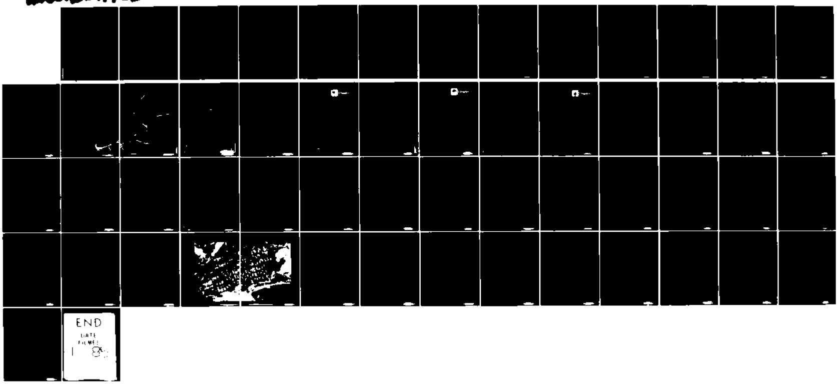

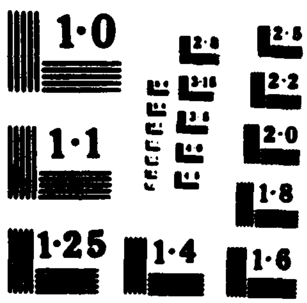
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Recreation Days		311	444	596	750	866	1,559

[1] Based upon Chaska feasibility report, Corps of Engineers, August 1973.

26. The net annual recreation benefit calculation will be the without-project calculations subtracted from the with-project calculations.

ANNUAL BENEFIT CALCULATION

27. A standard economic analysis and an interest rate of 7-3/8 percent were used to convert annual recreation days to average annual recreation benefits. In conjunction with the new NED benefit evaluation procedures for recreation (ER 1105-2-30, Federal Register, December 14, 1979), day-use values were calculated, under the Guidelines for Assigning Points for General Recreation, at $1.90 with the proposed trail development and $1.25 under existing conditions. Tables 8 and 9 show the annual recreation benefits, as calculated by this method, that could be expected with the proposed project and with the existing levee without the proposed project. Operation and maintenance costs were estimated at $.20 per visitor day for the proposed trail facilities. Net average annual discounted recreation benefits are $28,114.21 ($28, 976.81 with project, $862.60 without project).

Table 8

Annual Recreation Benefits (With Project)

Name of Project - Chaska, Minnesota, Flood Control Project
Interest Rate - .07375
Economic Life - 50 years

Determination of Unit Value for General Recreation

Estimated Day-Use Value - $1.90

Annual Recreation Benefits (Using Straight Line Growth)

Year	Visitation	Annual Benefits
1980	7,106	$ 13,501.40
1985	9,804	18,627.60
1990	12,938	24,582.20
1995	16,031	30,458.90
2000	19,344	36,753.60
2030	34,820	66,158.00

Accumulated Discounted Total Benefits - $381,708.22
Amortization Factor - .075914
Average Annual Discounted Recreation Benefits - $28,976.81
Average Annual Visitation - 20,756.73

Annual Operation and Maintenance Costs

Average Annual Visitation - 20,756.73
Projected O&M Per Visitor Cost - $.20
Average Project O&M Cost - $4,151.345

Table 9

Annual Recreation Benefits (Without Project)

Name of Project - Chaska, Minnesota, Flood Control Project
Interest Rate - .07375
Economic Life - 50 years

Determination of Unit Value for General Recreation

Estimated Day-Use Value - $1.25

Annual Recreation Benefits (Using Straight Line Growth)

Year	Visitation	Annual Benefits
1980	311	$ 388.75
1985	444	555.00
1990	596	745.00
1995	750	937.50
2000	866	1,082.50
2030	1,559	1,948.75

Accumulated Discounted Total Benefits - $11,362.94
Amortization Factor - .075914
Average Annual Discounted Recreation Benefits - $862.60
Average Annual Visitation - 934.19

Annual Operation and Maintenance Costs

Average Annual Visitation - 934.19
Project O&M Per Visitor Cost - $.20
Average Project O&M Cost - $186.837

ADDITIONAL REAL ESTATE NEEDED FOR RECREATION

28. In 1973, it was reported that Chaska was committed to preserving linear open space along the Chaska and East Creeks and on the river side of the proposed flood control levee. A recent check with Chaska's city planner confirmed their intent to continue in this direction. Federal assistance to develop trail facilities along East Creek could be made available in the future. East Creek will be used as a low-flow channel, thus making the addition project-related.

RECOMMENDED PLAN OF DEVELOPMENT

PROPOSED DEVELOPMENT

29. The proposed project consists of a trail system along the top of the levee in the Courthouse Lake area and beautification by incorporating overburden areas and natural vegetation. Where riprap is not required for erosion, the levee should be seeded to native prairie grass species, which grow to a height of approximately 6 to 8 inches and require virtually no maintenance. Because burning would not be possible, only prairie species that can be established without burning would be used.

30. An 8-foot-wide asphalt path would be established along the top of the levee and would extend from the western edge of the Chaska levee to Courthouse Lake and then continue around the lake in a short loop (plate G-1). The levee would continue past Courthouse Lake and tie into high ground a few hundred yards beyond. Plate G-2 shows how the existing levee will connect with the proposed levee, providing usable space for recreational activities. Chaska could easily maintain picnic grounds at Courthouse Lake as an area for passive recreational pursuits. Also shown is an overburden area (as described in EM 1110-2-301, 29 December 1972), which would not affect the structural integrity of the levee but would add to the attractiveness of the project in this area. By incorporating this overburden area, native floodplain vegetation would be allowed to grow up the sides of the levee and create a natural-appearing site conducive to birding, walking, and other activities.

31. Paving the trail would encourage bicycle traffic, which could help alleviate the present congestion and conflict between automobiles and bicycles in Chaska. The trail would also create a desirable flow pattern. Courthouse Lake would serve as a city park, and people could take lunches on their bicycles and ride to the park. There is ample parking near the lake, which would encourage people to drive there and then bicycle around the lake or to other portions of the area. The paved pathway around the lake would also encourage use by handicapped people, including those confined to wheelchairs.

32. The East Creek levee does offer trail development opportunities. However, there is already a trail system in place in the park. The park would be better served if the levee provided a physical boundary between the park and surrounding land uses. Therefore, no recreational developments are currently proposed for the East Creek levees.

MIX OF ACTIVITIES

33. Desirable forms of motorized recreational use in the project area present a potential problem. It is incongruent to establish greenways to provide pathways throughout the area and then permit machines to overrun the area. Similarly, encouraging people to enjoy the area by

hiking and bicycling via the trail system and then allowing interruption by noisy, smelly machines is not acceptable. The project sponsor would be expected to prohibit access by motorized vehicles if the recreation features are constructed.

FACILITY LOAD CRITERIA

34. The two predominant types of activities expected to occur on the proposed levee trail would create an estimated 69,640 activity occasions by the year 2030. This assumes maximum use based upon one person engaging in only one activity per visit. An estimate of the heaviest expected use of the trail was determined as follows:

a. $$\frac{\text{69,640 annual activity occasions}}{\text{180 recreation-day season}} = \text{387 activity occasions per season day}$$

b. $$\frac{\text{387 activity occasions per season day} \times \text{7 days per week} \times 0.60^{(1)}}{\text{2 days per weekend}}$$

c. $$\frac{813 \times 0.80^{(2)}}{\text{4 hrs. of peak use per weekend day}} = \text{163 people per hour on peak weekend day}$$

(1) Sixty percent of the recreational use would occur on the weekend.
(2) Assuming 80 percent of peak use would occur during 4 hours (i.e., 1 p.m. - 5 p.m. on weekend days).

35. Using the reported capacities of 850 to 1,000 cyclists per hour, as shown in the "Bikeways Planning Criteria and Guidelines," School of Engineering, University of California at Los Angeles, April 1972, the estimate of 163 people per hour for the proposed trail is an acceptable level of use.

FISH AND WILDLIFE CONSERVATION AND ENHANCEMENT

36. Fish and wildlife would be slightly and indirectly benefited by construction of the levee around Courthouse Lake. The lake has a "put and take" trout fishery. During floods it receives water containing debris and undesirable rough fish from the Minnesota River. The proposed levee would eliminate flooding by protecting the lake, and would therefore prevent rough fish and debris from entering.

FOREST RESOURCES AND OTHER VEGETATION PROGRAMS

37. The only vegetation programs would be those mentioned in the Proposed Development section, particularly the prairie grass establishment and use of an overburden or warp area.

COORDINATION WITH OTHER AGENCIES

38. No additional formal coordination was done with other agencies in the preparation of this study because there was no significant change

from the development proposed in the 1973 feasibility report. Informal coordination has taken place recently with Chaska's Park and Recreation Director and the Minnesota Department of Natural Resources (DNR) regarding their opinion of the proposed development plan and its role in the planning of the Minnesota Valley Trail. The general feeling concerning the project is positive. The Minnesota DNR is planning to make use of the proposed levee trail as a segment of the Minnesota Valley State Trail.

IDENTIFICATION OF SPECIAL PROBLEMS

39. Construction of the proposed East Creek levee would result in the conversion of park lands which have been developed using Land and Water Conservation Act Funds (LAWCON), a Section 6(f) conflict. A portion of the East Creek levee and the proposed inlet structure would be in Lions Park. No existing recreational facilities would be displaced by the levee. The levee would provide a physical boundary, separating the park from surrounding land uses, and would probably enhance the recreational experiences offered by the park. However, in similar instances, the National Park Service has determined that the levee would constitute a conversion. To resolve the conflict, lands must be purchased which are of equal monetary and recreational value to those lands being converted. The city of Chaska has been informed of the conflict, and the study is proceeding under the assumption that the National Park Service will rule that the levee is a conversion of park lands. No conflicts presently exist concerning the proposed levee trail system. The trail would be paved and access points would have gentle grades, so wheelchair patients, the elderly, and other people with physical limitations would be able to enjoy the Courthouse Lake area. Ramps, necessary for bicycles to enter existing parking lots, would be natural entrance points for wheelchairs.

COSTS

ESTIMATED COSTS FOR RECREATION FACILITIES

Table 10

Cost Estimate, Recreational Trail Along Levee
Chaska, Minnesota

Item	Unit	Quantity	Unit Cost	Total Est. Cost
1. Paving on new levee (1 mi)				
2. Paving on existing levee around Courthouse Lake (3,000 ft)				
3. Landscape plants in over-burden area	Job	Sum	--	$5,000
4. Signage				
Total construction cost				
Contingencies				
Engineering and Design				
Supervision and Administration				
Total Cost				

MANAGEMENT AND COST SHARING

CORPS RESPONSIBILITY

40. Section 4 of the Flood Control Act of 1944 (16 U.S.C. 460 d), as amended by Section 207 of the Flood Control Act of 1962, grants general permissive authority to construct recreational developments at all water resource developments. This law requires matching local participation in terms of money and/or lands that will equal the Federal share. If the local interests are not financially capable of participating, no Federal recreational development will be provided.

NON-FEDERAL RESPONSIBILITY

41. The non-Federal body will be required to sign a cost-sharing contract with the Federal Government before detailed design specifications and construction are developed. Attachment A is a draft of that document. Under Article 3, Section (a), payment by the city may be immediately in cash, may be in kind, or may be on an installment basis over a period not exceeding 50 years.

AESTHETICS

AUTHORITY

42. Preservation and enhancement of the environment, including avoidance of destruction or degradation, was established as an objective of Federal programs by Public Law 91-190. Therefore, it is the policy of the Corps that environmental quality be an equally important objective in the planning, design, and construction of Civil Works projects.

PURPOSE OF THE STUDY

43. This study will review the proposed project, determine its effect on the aesthetic environment, and develop landscaping alternatives to offset any adverse effects and enhance project features. The project is divided into three segments for this analysis: Chaska Creek, Courthouse Lake, and East Creek.

PROPOSED AESTHETIC MEASURES

44. The objectives of the measures are to:

a. Heal construction scars.

b. Harmonize the project with the surrounding area.

c. Control erosion.

d. Provide screening/enhancement of project features.

e. Provide for incidental wildlife habitat.

f. Separate conflicting land uses.

45. The Chaska Creek portion of the project consists of a vertical walled channel designed to carry swiftly moving flood flows. The channel would be fenced for public safety. No recreational developments are proposed in this report for this segment of the project.

46. The objective of the aesthetic measures along Chaska Creek would be to minimize the visual intrusion of the channel. One measure would be to use colored, vinyl-clad chain-link fence rather than galvanized. The fence line should have groupings of small trees and shrubs at irregular intervals. To give a more natural appearance, these groupings should have odd numbers of plants. Vines could also be established on the fence. There would be no attempt to completely hide the channel, but rather to create nodes of visual interest to offset

the intrusion of the channel. The ground cover used should match adjoining land uses: prairie grasses in rural/natural areas and bluegrass in urban, manicured areas.

47. Recreational development is proposed for the Courthouse Lake segment. The objective of aesthetic measures for this portion of the project would be to enhance available recreational opportunities. Trees and shrubs should be chosen for their aesthetic values, and placement would be designed to frame/screen views, provide shade, and separate uses. The levee would be planted with short prairie grass species and overburdened areas with trees and shrubs.

48. The East Creek segment of the proposed project consists of a grass-lined diversion channel between Brandondale Boulevard and Engler Boulevard. Between Engler Boulevard and Crosstown Boulevard, the natural streambed would not be modified. Overbank flow would be allowed and would be contained by a low levee between the creek and urban development to the south. There is an inlet structure at Crosstown Boulevard which would divert flood flows into a diversion tunnel. Another levee parallels Crosstown Boulevard. The objective of the aesthetic measures in this portion would be to provide wildlife habitat; screen the various structures, especially the inlet to the diversion tunnel; reestablish and maintain natural vegetation; and blend the project into the surrounding area.

49. The levee along the southern boundary of Lions Park would serve as a physical boundary between the park and the urban development. Much of the levee would parallel Ravoux Road. Recommended ground covers would be prairie grasses, crown vetch, or clover. These would require minimal maintenance and are common along roadsides in the area. Occasional shrub groupings should be located on the urban side of the levee. Overburdened areas may be required. Shrubs should be placed around the structures at the ends of the grasslined channel. The channel itself should look relatively natural.

50. The levee paralleling Crosstown Boulevard should be planted with low maintenance ground covers such as clover and crown vetch. However, the portion of the levee that is in Lions Park should be planted to match the existing park's ground cover.

51. In the area between the levee and the creek, emphasis should be placed on reestablishing native vegetation. Most of these plantings here would be in conjunction with healing construction scars. The only extensive planting proposed would be native trees and shrubs along an area approximately 200 feet long by 50 feet wide, paralleling Crosstown Boulevard. The new trees should be blended into the existing treeline for a natural appearance. One reason for the plantings in this area would be to screen the inlet structure from Lions Park. Therefore, the shrub layer should be rather thick.

52. The most dominant feature of the East Creek portion of the project would be the inlet structure for the diverison tunnel. The walls would be up to 15 feet high, and steel trash racks would be required. The structure would be at or below grade, and would be fenced on three sides for public safety. A number of aesthetic measures can be incorporated into the design of the structure which would make it much less visible. Colored concrete could be used to soften the gray color, and the trash racks and fencing could also be colored. For example, the concrete could be colored dark brown or rust and the trash racks made of corten steel. The fence could be heavily screened with shrubs and vines except where access is needed for maintenance.

53. The outlet channel for the East Creek diversion would be grass-lined. Random tree and shrub clumps should be planted along the top. The design should provide a natural transition into riparian vegetation along the Minnesota River.

54. Table 11 lists plant materials which would be appropriate for use at Chaska. Most of these materials are native to the area. This list is not intended to be inclusive: varieties and cultivars of the recommended plant species may be used and may even be more appropriate, depending on the site. The specific materials to be used at a particular site should be selected on the basis of their intended purpose (e.g., native vegetation, screening). The Fish and Wildlife Service has recommended an environmental quality plan which includes plantings. This plan should be used to guide the selection and placement of plant materials.

Table 11

Recommended Plant List

Trees	
Acer saccharinum	Silver Maple
Acer saccharum	Sugar Maple
Acer rubrum	Red Maple
Quercus bicolor	Swamp White Oak
Fraxinus nigra	Black ash
Fraxinus pennsylvanica	Green ash
Salix species	Willows
Betula nigra	River birch
Juniperus virginiana	Red cedar
Thuja occidentalis	Arborvitae
Tilia species	Linden/Basswood

Shrubs, Small Trees	
Acer Ginnala	Amur maple
Alnus rugosa	Alder
Lonnicera species	Honeysuckles
Caragana species	Peashrubs
Cephalanthus occidentalis	Buttonbush
Cornus sericea	Red osier dogwood
Juniperus species	Junipers
Malus species	Crab apples
Rosa species	Shrub roses
Viburnum dentatum	Arrowwood
Viburnum lentago	Nannyberry
Viburnum lantana	Wayfaring bush
Symphoricarpus albus	Snowberry
Amelanchier species	Serviceberry

Vines

<u>Vitis riparia</u>	Riverbank grape
<u>Parthenocissus quinquefolia</u>	Virginia creeper
<u>Clematis virginiana</u>	Virgin's bower

Ground Covers

Clover

Crown Vetch

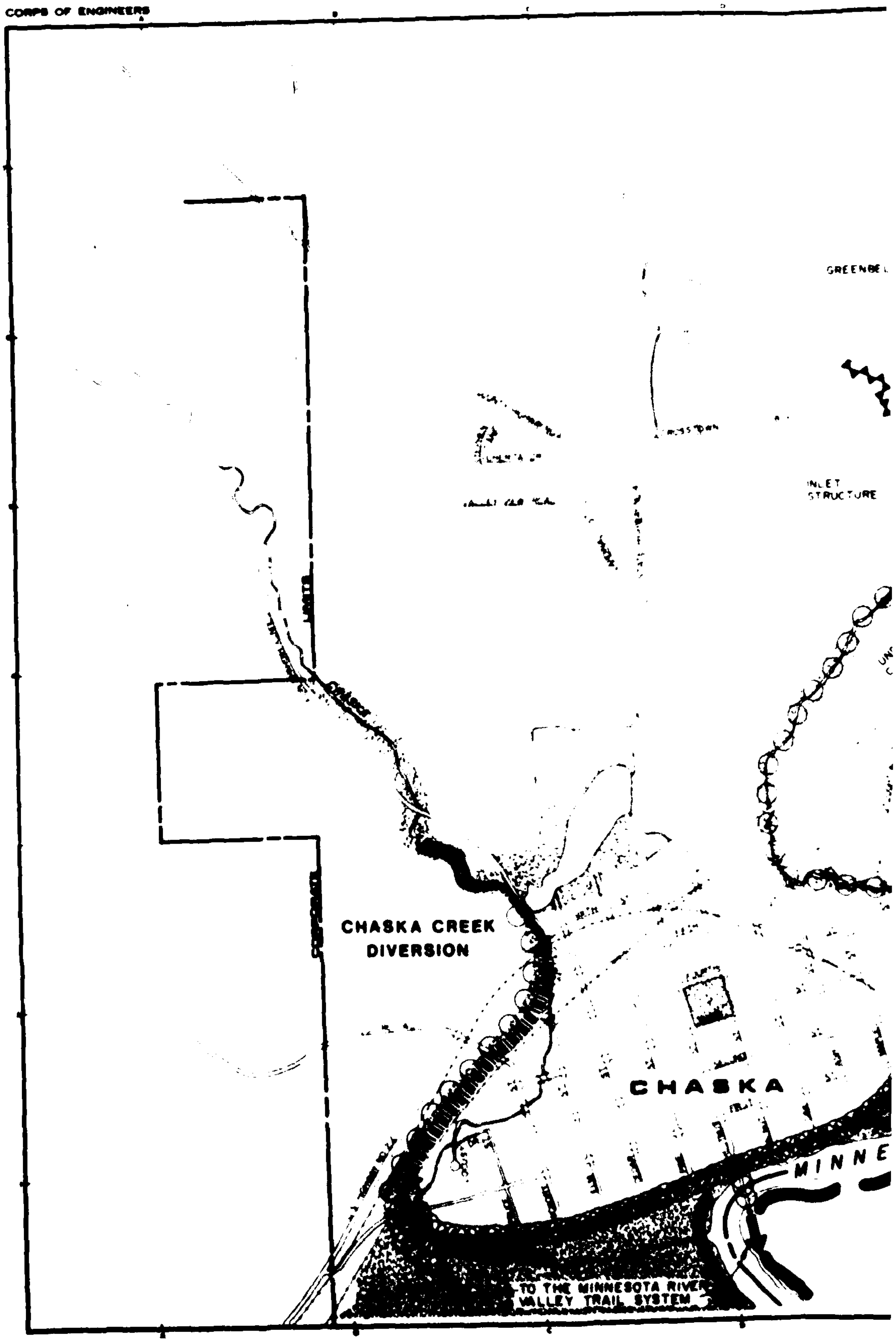
Prairie grasses

Daylily (<u>Hemerocallis</u>)

Bluegrasses

Rye grasses

CORPS OF ENGINEERS



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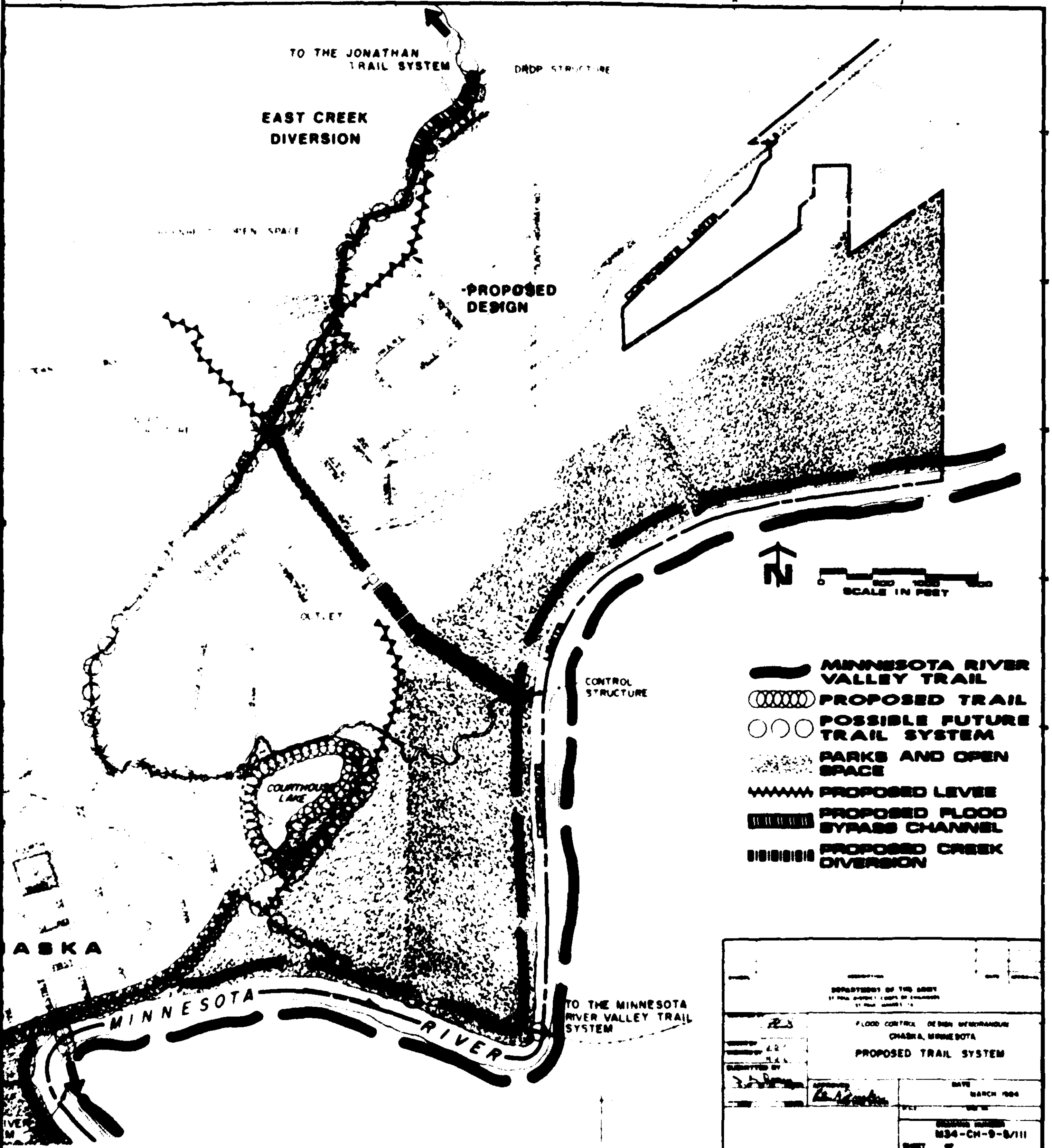

PLATE 6-1

APPENDIX H

LOCAL COOPERATION LETTERS

This appendix contains copies of letters from the city of Chaska which show their support for the project. The letter dated 21 February 1984 is their specific letter of intent, and it directly addresses their willingness to share project costs in conformance with the current policy on cost-sharing.

Chaska

WILLIAM M. RADIO
City Administrator

May 7, 1981

Department of the Army
St. Paul District
Corps of Engineers
District Engineer
1135 U.S. Post Office and
Custom House
St. Paul, MN. 55101

Dear Sirs:

After completing a preliminary meeting with representatives of the Corps of Engineers and having attended and heard the comments of the affected property owners in Chaska at the Corps public hearing of May 6, 1981, we are pleased to express our support for the Corps project for the Minnesota River at Chaska, including improvement of the East and West Chaska Creeks.

We understand that the project has been approved for construction by Congress with funding considerations to be made at the appropriate time. The present estimated cost of the project is approximately 16 million dollars with 3 million dollars of that to be the approximate share expected to be produced by the City.

Our only concern with the project is our understanding that 1985 would be the soonest construction could begin. We would like to emphasize to you that our support for the project is based upon the need within the City and that anything that can be done to expedite the timing of the project would be supported and greatly appreciated by us.

Thank you for your efforts on behalf of our citizens.

Sincerely,

Tracy D. Swanson

Tracy D. Swanson
Mayor, City of Chaska

TDS:jw

City Of Chaska Minnesota 205 East Fourth Street 55318 Phone 612-448-2851

August 19, 1982

Department of the Army
St. Paul District
Corps of Engineers
District Engineer
1135 U.S. Post Office and Custom House
St. Paul, Minnesota 55101

Dear Sirs:

We are pleased to express our continued support for the Corp project for the Minnesota River at Chaska, including improvement of the East and West Chaska Creeks.

We understand that the project has been approved for construction by Congress with funding consideration to be made at the approximate time. The City of Chaska is willing to serve as the local sponsor and to cost-share the construction of the project as we have discussed in the past.

Our only concern with the project is our understanding that 1985 would be the soonest construction could begin. We would like to emphasize to you that our support for the project is based upon the need within the City and that anything that can be done to expedite the timing of the project would be supported and greatly appreciated by us.

Thank you for your efforts on behalf of our citizens.

Sincerely,

Tracy D. Swanson

Tracy D. Swanson
Mayor, City of Chaska

TDS:jai

Chaska

WILLIAM M. RADIO
City Administrator

November 18, 1982

Colonel Edward G. Rapp
Department of the Army
St. Paul District
Corp of Engineers
1135 U.S. Post Office and Custom House
St. Paul, Minnesota 55101

Dear Colonel Rapp:

The City of Chaska is in receipt of the main report from the Corp of Engineers on the Minnesota River at Chaska, Minnesota dated August 1982, as well as the technical appendixes on the same project of the same date.

This letter is to inform you that the City of Chaska always has and continues to support this project, and considers it of the highest priority within the City.

Thank you for keeping us informed of its progress, and please let us know if you need any other information from us.

Sincerely,

William M. Radio

William M. Radio
City Administrator

WMR:jai

City Of Chaska Minnesota 205 East Fourth Street 55318 Phone 612-448-2851

Chaska

WILLIAM M. RADIO
City Administrator

Captain Douglas D. Gransberg
U.S. Army Corps of Engineers
St. Paul District
1135 U.S. P.D. & C.H.
St. Paul, MN 55101

Dear Captain Gransberg:

The Chaska Planning Commission and the Park, Recreation and Natural Resource Commission reviewed the proposed alternate design of the [illegible] Diversion Routing which would divert the flood flows under [illegible] east side of the City and then directly to [illegible]. Both the Planning Commission and the Park Board informed the City Council of their support of the proposed alternate design.

The City Council held a public informational meeting on Monday, January 9, 1984, at which you and members of your staff were present to discuss the present design and the proposed design with the citizens of Chaska.

The City Council at its January 16, 1984 meeting directed me to inform the Corp that the City of Chaska supports the proposed alternate design of the East Creek Diversion Routing.

If you have any further questions, please contact me. Looking forward to seeing you at the February 7th meeting.

Sincerely,

William M. Radio

William M. Radio
City Administrator

WMR:jai

City Of Chaska Minnesota | 205 East Fourth Street 55318-2094 | Phone 612-448-2851

Chaska

February 21, 1984

Colonel Edward G. Rapp
District Engineer
U.S. Army Engineer District, St. Paul
1135 U.S. Post Office and Custom House
St. Paul, MN 55101

RE: MINNESOTA RIVER AT CHASKA, MINNESOTA, FLOOD CONTROL PROJECT

Dear Colonel Rapp:

This will acknowledge that the City of Chaska is willing to serve as the local sponsor for the Chaska flood control project, authorized by the 1976 Water Resources Development Act (Public Law 94-587). The City understands and agrees with the project features as proposed by the Corps and defined in the project documents and August 1982 limited reevaluation report. The City of Chaska is willing to fulfill the legal requirements of local cooperation and, subject to obtaining its share of local funding, to participate in cost sharing and financing as outlined in the following paragraphs.

Local Cooperation Requirements

1. The City shall provide without cost to the United States all lands, easements, and rights-of-way, including suitable ponding, borrow, and disposal areas as determined by the Chief of Engineers to be necessary for the construction of the project.

2. The City shall provide the necessary lands for recreation development, subject to the condition that where the appraised value of those lands is less than 50 percent of the total first cost of recreation development, a cash contribution will be made to bring the non-Federal share to at least 50 percent of the total first cost of recreation development. (This requirement will change in the GDM to reflect current policy.)

3. The City shall hold and save the United States free from damages due to the construction works, except damages due to the fault or negligence of the United States or its contractors.

4. The City shall maintain and operate the flood control project and the recreation facilities after completion in accordance with regulations prescribed by the Secretary of the Army.

5. The City shall provide without cost to the United States all alterations and relocations of buildings, utilities, sewers, highway bridges and roads, including any modification of the Minnesota Highway 41 embankment and culvert at East Creek as may be required by the Chief of Engineers to ensure the proper functioning and safety of the Federal improvements on East Creek, and any other special facilities resulting in a local betterment.

6. The City shall prescribe and enforce regulations to prevent obstruction or encroachment on channels and interior ponding areas which would reduce their flood-carrying capacity or hinder maintenance and operation.

7. The City shall publicize floodplain information in the areas concerned and provide this information to zoning and other regulatory agencies for their guidance and leadership in preventing unwise future development in the floodplain and in adopting such regulations as may be necessary to ensure compatibility between future development and protection levels provided by the project.

8. The City shall inform affected interests at least annually regarding the limitation of the protection afforded by the project.

9. The City shall comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Laws 91-646, approved January 2, 1971, in acquiring lands, easements, and rights-of-way for construction and subsequent maintenance of the project and shall inform affected persons of pertinent benefits, policies, and procedures in connection with said Act.

10. The City shall comply with Section 601 of Title VI of the Civil Rights Act of 1964 (Public Law 88-352) and the Department of Defense Directive 5500.11 issued in connection with the maintenance and operation of the project.

<u>Cost Sharing and Financing Requirements</u>

The City will contribute, during the period of construction, a percentage of the total projects costs that conform to the cost sharing and financing policy developed by the administration and the Congress for flood control projects. This contribution will be in the form of credits for costs incurred in meeting the requirements of paragraphs 1 and 5 above, plus cash payments.

Such total project costs shall not include recreation development costs, which are to be cost shared in accordance with Public Law 89-72. The City recognizes that the provision of lands, easements, and rights-of-way, as well as necessary relocations in connection with the local flood control project, is a non-Federal responsibility, and the City will bear the full cost thereof, even if it exceeds the agreed upon percentage of the project's total construction cost.

Prior non-Federal construction costs, insofar as they contribute to the reduction of flood damages in the project area, will be appraised, evaluated, and credited to the City in an amount to be negotiated between representatives of the City and the Corp of Engineers, if they meet one or more of the following criteria: The work to which the cost is attributed is required in the authorizing project documents or the general design memorandum; the work can be incorporated into approved project features or substituted for authorized features of the project and reduces Federal costs of project features.

Prior to the start of construction, execution of a Local Cooperative Agreement (Section 221, Public Law 91-611) will be required. That agreement will reflect the cost-sharing provisions specified above as well as other items of local cooperation as required by the authority provided in the 1976 Water Resources Development Act (Public Law 94-587).

It is understood that this does not preclude any change in cost sharing for the project authorized by Congress in legislation enacted subsequent to the date of the agreement, nor shall it preclude the City from using Federal or State programs existing or hereafter created to provide funds for the City's share of the project costs, provided such use is not prohibited by other Federal or State laws.

The City of Chaska is by law empowered to provide the non-Federal cooperation assurance and financing required by the Federal Government for flood control projects. The City will provide its share of non-Federal funds from value established for land provided and relevant pre-existing flood control facilities, new facilities constructed by local governmental agencies as part of the flood control project, general taxation, special assessments against benefited properties, and other available resources.

Sincerely,

Tracy D. Swanson
Mayor of Chaska

TDS:jai

APPENDIX I

EVALUATION OF EXISTING LEVEES

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TABLES

FIGURES

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DESCRIPTION OF CHASKA LEVEE SYSTEM

1. The existing flood control system was constructed over a 16-year period starting in 1953 and ending in 1969. It consists of approximately 9,550 feet of levee, two permanent pumping stations and numerous flood gates on storm sewers and culvert drains. The majority of the existing levees are grass covered with varying top widths and have side slopes ranging from steep to relatively mild. The levees were generally constructed of random fill consisting primarily of semi-pervious to impervious materials.

2. Based on the evaluation presented in this report, the existing levee system is composed of 6 separable levee reaches, see figure 1, which are independent of each other with regard to probable flood damage stages and permissible top of freeboard elevations.

REACH 1

3. The levee configuration in this reach varies as follows: top width from 8 to 17 feet; riverward slope from 1V on 1.8H to 1V on 2.9H; and landward slope from 1V on 1.5H to 1V on 3H. Erosion protection is generally provided by a grass cover with some riprap in the area around the Highway 41 (Chestnut Street) bridge. During the 1969 flood the Minnesota River crested at elevation 720.3. At this elevation small sand boils were noted by local interests from about Elm Street to Maple Street.

REACH 2

4. Existing levees in this reach extend from the abandoned railroad embankment north to East Creek along the west end of Courthouse Lake, and also from Beech Street to about where Fifth Street would intersect with East Creek. The levees in this reach are characterized by top widths ranging from 12 to 20 feet, riverward slopes of 1V on 1H to 1V on 3.5H, and landward slopes of 1V on 2H to 1V on 3.5H. Erosion protection is provided by a grass cover. Extensive temporary closures must be erected in this reach if water levels were to exceed the existing ground surface elevation along East Creek from Beech Street to Courthouse Lake.

REACH 3

5. An existing levee extends for about one-third of this reach. Erosion protection is provided by a grass cover. A temporary closure (approximately 400 feet in length) would be required to reach elevation 727 upstream of the existing levee.

REACH 4a

6. The existing levee in this reach is adjacent to East Creek from Sixth Street and extends downstream for about 350 feet. Erosion protection is provided by a grass cover. A closure of approximately 500 feet would be required from the downstream end of the levee to high ground.

REACH 4b

7. The existing levee in this reach is generally located along East Creek and extends from Beech Street to about 150 feet upstream of Boldt Street. Erosion protection is provided by a grass cover. A 100-foot temporary closure would be necessary to provide protection to elevation 724.1 at Beech Street.

REACH 5

8. Reach 5 extends from the downstream end of Reach 4 and ends where the existing levee abuts a large embankment about 250 feet east of Boldt Street. Erosion protection is provided by grass cover.

GEOTECHNICAL EVALUATION OF THE CHASKA LEVEE SYSTEM

9. The following geotechnical evaluation was accomplished primarily for economic analysis purposes and should not be considered a state-of-the-art geotechnical engineering evaluation of the existing barrier. The basic ojective of the evaluation is to establish the lowest probable damage stage and permissible top of freeboard for each separable reach of the existing flood barrier. The probable damage stage is defined as the lowest river stage (flood elevation) at which interior flood damages are likely to occur if there is no significant human intervention. Once the probable damage stage and permissible top of freeboard have been established, and freeboard appropriately applied, the economists utilize this data to determine project feasibility. The evaluation is based primarily on past experience with emergency levees as well as on several questionable assumptions. This results in an increase (to an unknown extent) in the level of risk associated with the existing barrier when compared to the level of risk associated with a flood barrier designed and constructed to current Corps of Engineers criteria.

10. The geotechnical evaluation of the existing flood barrier at Chaska was based on the assumptions listed below.

a. The barrier is not being certified as providing any assured level of permanent protection.

b. The evaluation is for the existing (as is) condition, with reasonable human intervention permitted only in the freeboard range.

c. The existing barrier does not have to satisfy any factor of safety criteria.

d. Ownership, maintenance, and operational procedures are not important.

e. Experience with emergency levees constitutes an adequate basis for judging the probable performance of the existing barrier. Detailed subsurface investigation and soil design analyses are, therefore, not required.

f. The absence of an inspection trench beneath the barrier will not affect the performance of the barrier.

g. Existing provisions for interior drainage are not important and do not need to be evaluated.

11. Data used to evaluate the existing barrier included 1979 surveyed sections, 1982 topography (excluding areas adjacent to East Chaska Creek west of Courthouse Lake), soil borings taken from 1973 through 1983, the 1969 Project Engineer's flood report, a field inspection of the levee system, and cross sections and spot elevations taken during the field inspection.

12. Levee sections were evaluated based on fitting a template with 1V on 3H sideslopes and a 10-foot top width within the levee section. The maximum top of template elevation (probable flood damage stage) was determined without the template protruding beyond the limits of existing fill. It was found that critical elevations and locations were not governed by the template evaluation method but were controlled by the closures and past seepage-related problems.

13. Each separable reach of the flood barrier system is subject to creek flood events, Minnesota River flood events, or to a combination of the two. Therefore, this evaluation identifies potentially critical areas in each reach for all sources of flooding. Temporary earthfill or sandbag closures that are 200 feet or less in length are considered reasonable for Minnesota River flood events; however, flood events on the creeks are flash-flood situations with insufficient warning time for the installation of temporary closures. The table I-1 summarizes the critical flood elevations discussed below. Figure 1 identifies the locations of these critical elevations. The selection of locations has been coordinated with Hydraulics to insure that the critical areas were identified.

REACH 1

14. Two potentially critical locations exist within this reach and are described in the following paragraphs.

15. The ground surface at the upstream end of the levee adjacent to Chaska Creek is at about elevation 719.5. A temporary closure cannot be provided at this location for Chaska Creek flood events because of their flash-flood nature. A temporary, freeboard closure for Minnesota River flood events would have to be about 620 feet long, which is considered unreasonable for a temposary closure. Therefore, at this location, the existing ground elevation of 719.5 is considered to be the probable flood damage stage and also the maximum permissible top of freeboard elevation for Chaska Creek and Minnesota River flood events.

16. This location includes the two pump stations (at Elm Street and between Ash and Maple Streets) and the area between the two pump stations, where the ground surface at the landward toe of the existing levee is the lowest. Small sand boils, indicative of incipient seepage-related problems, were noted at the landward toe of the levee in these locations during the 1969 flood (crest elevation 720.3). In order to provide some margin of safety for the incipient seepage-related problems reported, the permissible head differential across the levee was set at two-thirds of the maximum head differential across the levee during the 1969 flood. This results in a maximum permissible top of freeboard and a probable flood damage stage elevation of 715.5 at the pump station locations.

REACH 2

17. Two critical locations were defined within this reach and are located along East Creek. The location critical to Minnesota River flood events is 20 feet west of the existing levee, which ends at the creek with a ground surface at elevation 718.5. The ground surface just west of the Beech Street bridge is at elevation 720.0 and is the controlling location for East Creek flood events. Placement of closure materials within these areas would necessitate placing over 600 lineal feet of material. This is considered unreasonable for the temporary closures for Minnesota River floods and no closures are considered reasonable for East Creek floods due to their flash-flood nature. Therefore, these elevation are the probable flood damage stage and maximum permissible top of freeboard elevations.

REACH 3

18. The critical area of this reach for Minnesota River floods is located on Ash Street where it ends at East Creek. The maximum permissible top of freeboard and probable flood damage stage elevation is 723.8, since this is the lowest ground surface elevation and any closure would require placing over 400 lineal feet of material. The critical location for East Creek floods is just upstream of the Sixth Street bridge where the ground surface is at elevation 724.0. This is the probable flood damage stage and the maximum permissible top of freeboard because of the flash-flood nature of the creek.

REACH 4a

19. The critical location and elevation of this reach for Minnesota River floods is at Beech Street where the ground surface is at elevation 721.1. Since placement of any closure materials would exceed 200 feet, this elevation is both the maximum permissible top of freeboard and probable flood damage stage elevations. For East Creek floods the critical location is just downstream of the Central and Northwestern railroad bridge where the ground surface is at elevation 724.0. This is the maximum permissible top of freeboard and probable flood damage stage elevation due to the flash-flood nature of the creek.

REACH 4b

20. The critical location of this reach for both Minnesota River and East Creek floods is at the Beech Street bridge where the ground surface is at elevation 721.1. This is the maximum permissible top of freeboard and probable flood damage stage elevation for East Creek floods, however, a 200-foot temporary closure could be constructed to elevation 724.1 for Minnesota River floods. Therefore, the maximum permissible top of freeboard elevation is 724.1 and the probable flood damage stage is at elevation 721.1.

REACH 5

21. The critical location of this reach for both Minnesota River and East Creek floods is at the lowest point of the flood barrier system which is located about 30 feet west of Boldt Street where the top of levee elevation is at about 717.3. This is the maximum permissible top of freeboard and probable flood damage stage elevation for this reach.

PROBABLE LIFE OF THE EXISTING BARRIER

22. Assuming reasonable maintenance, the probable life of the existing barrier (all reaches) will be either the time at which the cumulative probability of a flood event exceeding the top of freeboard elevation reaches 90% or 25 years, whichever is less.

ADDITIONAL COMMENTS

23. Because of the assumptions in the evaluation of the five levee reaches, it should be recognized that reliance on the existing barrier to the above elevations involves greater risk than would be associated with a barrier designed and built to current Corps of Engineers criteria.

HYDROLOGY AND HYDRAULIC EVALUATION OF EXISTING BARRIER

GENERAL DESCRIPTION OF DRAINAGE AREA

24. Chaska is located in the floodplains of the Minnesota River, Chaska Creek and East Creek.

25. The Minnesota River has a mild slope with a gradient of about 1/2 - 1 foot per mile. Chaska Creek has a gradient of about 40 feet per mile and East Creek has a gradient of about 32 feet per mile.

FLOODS AND FLOOD CHARACTERISTICS

26. Due to the large drainage area, floods on the Minnesota River rise and recede slowly, on the order of 8 to 20 days for a large flood ascending limb with a recession of several weeks. The small size of Chaska Creek and East Chaska Creek results in a peak being reached in less than a day, with a recession taking a day or more.

27. Major floods at Chaska primarily occur on the Minnesota River, with major historical events happening in 1951, 1952, 1957, 1962, 1965, 1968 and 1969. Except for a June event in 1957, and October of 1968, all the remaining events occurred in April as a result of snowmelt. Chaska Creek and East Chaska Creek experienced a significant flood event in July 1951, with overflow occurring in two sections of Chaska. More detailed descriptions are available on pages 4A-2 to 4A-11 of the limited reevaluation report.

FLOOD STAGE FREQUENCY RELATIONSHIPS

28. The Minnesota River water surface profile adjacent to the barrier during a flood event is gently sloping (less than 1-1/2 foot difference). In contrast, the Chaska Creek and East Creek water surface profiles are relatively steep. Flood stage frequency information for Chaska is shown on figures 2 through 11, inclusive, and tables I-2 and I-3. Tables I-2 and I-3 are provided because of the large differences in water surface elevations from the upstream end to the downstream end of reaches 3 and 4a. The coincidental relationships for East Creek and Chaska Creek versus the Minnesota River, since the curves cross, are showing the highest elevation for the same frequency. The development of the hydrologic and hydraulic information for the relationship shown on the plates is discussed in greater detail in the Hydrology Appendix and the Hydraulic Appendix in this report and in the Chaska, Minnesota, Limited Reevaluation Report.

RELIABILITY OF FLOOD FORECASTS

29. The advance notice and the reliability of flood forecasts depend on the source of the flooding threat: Minnesota River, Chaska Creek or East Creek. The advance notice for high Minnesota River runoff would

should be on the order of a week or more. This is in contrast to the local runoff for East Creek and Chaska Creek for which the advance notice would be more on the order of 12-24 hours. Since Chaska is not a National Weather Service forecast point, reliability of forecasts becomes a factor in that Chaska would only have an indication of a possible flood problem based on stages at Mankato and Jordan. In any event, Chaska residents will not likely take any action on closure structures for flooding from East Creek and Chaska Creek. For Minnesota River flooding, sufficient time would be available for the installation of closure structures provided that the effort required is not significant.

RISK AND HAZARD OF A POTENTIAL LEVEE FAILURE

30. The risk and hazard associated with potential levee failure at Chaska varies from one reach to another as shown on table I-4. There would be primarily property damage with potential for loss of life or catastrophic damages depending on the reach. A summary of risk and hazard information, top of freeboard elevation, freeboard allowance, head of water on the barrier, and zero damage elevations are shown in the aforementioned table.

FREEBOARD REQUIREMENTS

31. It has been general practice in the design of levees to adopt uniform freeboard allowance above the design water surface profiles. These freeboard allowances have not been standardized, but the values most commonly adopted by the Corps of Engineers have been 2 feet for agricultural levees and 3 feet for urban flood protection structures. As discussed in EM 1110-2-1601 and CWB 54-14, freeboard allowance should not be an arbitrary number added on to levee design height. Freeboard allowance should be considered for each separate project based on the following factors:

a. the reliability of the gage data and the hydraulic analysis;

b. potential wind and wave set ups;

c. channel restriction and expansions;

d. channel velocities;

e. flood frequency stage variations in the water surface profiles; and,

f. risk of loss of life and catastrophic damage should the levees fail.

Based on the above considerations, a 3-foot levee freeboard criteria was selected. For locations where levees do not exist and where the

installation of a temporary closure structure is unreasonable, the controlling ground elevation is used, without freeboard, for this analysis.

CUMULATIVE PROBABILITY OF LEVEE OVERTOPPING

32. A cumulative probability of levee overtopping was conducted in accordance with procedures presented in Appendix 10 of the Water Resources Council Bulletin 17B dated September 1981. The results of the cumulative probability for levee overtopping are listed in table I-5.

CONCLUSIONS

33. The conclusions for each of the reaches designated for the existing levee evaluation are discussed below for existing hydrologic and hydraulic conditions.

a. Reach 1 - On the basis of the top of freeboard elevation of 719.5 recommended in the geotechnical evaluation (critical location 1, figure 1), the highest level of credit for the existing barrier system at critical location 1 should be elevation 719.5 since this is the point of incipient flow into the area landward of the reach 1 existing emergency levee. As shown on figure 2, the point of incipient flow has a recurrence interval of less than 3 years. Based on table I-5, there is an 85% cumulative probability that a flood event having a recurrence interval of 3 years will occur in a 5 year time interval and a 100% cumulative probability that a flood event having a recurrence interval of 3 years will occur in a 20 year time interval. On the basis of the top of freeboard elevation of 715.5 recommended in the geotechnical evaluation (critical location 2, figure 1) the highest level of credit for the existing barrier system at critical location 2 should be elevation 712.5, allowing for the recommended 3 feet of freeboard for Minnesota River flood events. As shown on figure 3, a flood stage of 712.5 has a recurrence interval of less than 7 years. Based on table I-5, there is a 50% cumulative probability that a flood event having a recurrence interval of 7 years will occur in a 5 year time interval and a 94% cumulative probability that a flood event having a recurrence interval of 7 years will occur in a 20 year time interval. Coincidental elevation frequency curves for with and without the existing levee system conditions are shown on figure 2.

b. Reach 2 - On the basis of the top of freeboard elevation of 718.5 recommended in the geotechnical evaluation (critical location 3, figure 1), the highest level of credit for the existing barrier should be elevation 718.5 since this is at the point of incipient flow into the area landward of the reach 2 emergency levee system. As shown on figure 4, the point of incipient flow has a recurrence interval of less than 33 years. Based on table I-5, there is a 16% cumulative probability that a flood event having a recurrence interval of 33 years

will occur in a 5 year time interval and a 49% cumulative probability that a flood event having a recurrence interval of 33 years will occur in a 20 year time interval. Coincidental elevation frequency curves for with and without the existing levee systems conditions are shown on figure 4.

c. Reaches 3 and 4a - On the basis of the top of freeboard elevation of 724.0 recommended in the geotechnical evaluation (critical locations 6 and 8, figure 1), the highest level of credit for the existing barrier should be elevation 724.0 since this is at the point of incipient flow into the area landward of the reach 3 emergency levee system. As shown on figure 6, a flood stage of 724.0 has a recurrence interval of less than 2 years. Based on table I-5, there is a 97% cumulative probability that a flood event having a recurrence interval of 2 years will occur in a 5 year time interval and a 100% cumulative probability that a flood event having a recurrence interval of 2 years will occur in a 20 year time interval. Coincidental elevation frequency curves for with and without the existing levee system conditions are shown on figure 6.

d. Reach 4b - On the basis of the top of freeboard elevation of 724.1 recommended in the geotechnical evaluation (critical location 9, figure 1), and allowing for the recommended 3 feet of freeboard for Minnesota River flood events or a top of freeboard elevation of 721.1 and no freeboard for East Creek flooding since this is the point of incipient flow into the area landward of the reach 4b emergency levee system, the highest level of credit for the existing barrier should be elevation 721.1. As shown on figure 8, a flood stage of 721.1 has a recurrence interval of less than 59 years. Based on table I-5, there is a 9% cumulative probability that a flood event having a recurrence interval of 59 years will occur in a 5 year time interval and a 30% cumulative probability that a flood event having a recurrence interval of 59 years will occur in a 20 year time interval. Coincidental elevation frequency curves for with and without the existing levee system conditions are shown on figure 8.

e. Reach 5 - On the basis of the top of freeboard elevation of 717.3 recommended in the geotechnical evaluation (critical location 10, figure 10), and allowing for the recommended 3 feet of freeboard, the highest level of credit for the existing barrier should be elevation 714.3. As shown on figure 10, a flood stage of 714.3 has a recurrence interval of less than 11 years. Based on table I-5, there is a 36% cumulative probability that a flood event having a recurrence interval of 11 years will occur in a 5 year time interval and a 83% cumulative probability that a flood event having a recurrence interval of 11 years will occur a 20 year time interval. Coincidental elevation frequency curves for with and without the existing levee conditions are shown on figure 10.

34. For future hydrologic and hydraulic conditions, the conclusions for each of the reaches designed for this analysis would be similar to those presented in the previous paragraph. With future conditions, the coincidental elevation frequency relationships are slightly higher in elevation when compared to existing conditions. The future conditions elevation frequency relationships for with and without the existing levee system conditions are shown on figures 3, 5, 7, 9 and 11 for reaches 1, 2, 3 and 4a, 4b, and 5, respectively.

		[illegible]		[illegible]		[illegible]	
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		[illegible]	[illegible]				
				[illegible]	[illegible]	[illegible]	[illegible]
				[illegible]	[illegible]	[illegible]	[illegible]
				[illegible]	[illegible]	[illegible]	[illegible]
				[illegible]	[illegible]	[illegible]	221.1
				[illegible]*	[illegible]	[illegible]*	[illegible]

TABLE I-2

Water Surface Elevations for Both With
and Without the Existing Levee Conditions
Reach 3

Section[1] Number	Distance[2]	El Min[3] (feet)	Existing[4] 20-Percent Chance Flood	Future[5] 20-Percent Chance Flood	Existing 10-Percent Chance Flood	Future 10-Percent Chance Flood	Existing 4-Percent Chance Flood	Future 4-Percent Chance Flood	Existing 2-Percent Chance Flood	Future 2-Percent Chance Flood	Existing 1-Percent Chance Flood	Future 1-Percent Chance Flood	Existing 0.2-Percent Chance Flood	Future 0.2-Percent Chance Flood
45.70	2280	716.90	722.33	722.59	722.77	723.15	723.33	723.72	723.75	724.20	724.18	724.62	729.60	730.80
47.30	2650	717.10	724.21	724.64	724.58	724.89	725.01	725.27	725.29	725.60	725.59	725.90	729.60	730.80
47.55	2675	717.10	724.46	724.66	724.78	725.06	725.17	725.42	725.55	725.77	725.72	726.01	729.60	730.80
47.60	2680	717.60	724.36	724.55	724.69	725.01	725.13	725.40	725.42	725.73	725.71	726.02	729.60	730.80
47.80	2700	717.60	724.75	724.93	725.05	725.30	725.40	725.62	725.63	725.90	725.89	726.17	729.60	730.80
47.85	2705	717.60	724.59	724.79	724.91	725.17	725.28	725.52	725.56	725.82	725.81	726.10	729.60	730.80
48.75	2795	718.00	725.26	725.32	725.42	725.64	725.73	725.92	725.96	726.10	726.17	726.62	729.60	730.80
50.20	2960	719.30	726.13	726.33	726.47	726.76	726.94	727.05	727.07	727.24	727.23	727.37	729.60	730.80

(1) Location of cross section is shown on plate 48-10 in the Chaska, Minnesota, Limited Reevaluation Report.
(2) Distance upstream of cross section 20.9
(3) Minimum elevation in the main channel.
(4) Existing hydrologic and hydraulic conditions
(5) Future hydrologic and hydraulic conditions

TABLE I-3

Water Surface Elevations for Both With and Without the Existing Levee Conditions

Reach [illegible]

Section Number	Distance	El min[3] Feet	Existing[4] 20 Percent Chance Flood	Future[5] 20 Percent Chance Flood	Existing 10-Percent Chance Flood	Future 10 Percent Chance Flood	Existing 5 Percent Chance Flood	Future 5 Percent Chance Flood	Existing 2 Percent Chance Flood	Future 2 Percent Chance Flood	Existing 1 Percent Chance Flood	Future 1 Percent Chance Flood	[illegible]
[illegible]	485	710.36	716.37	716.66	716.89	717.20	716.89	[illegible]	720.20	720.80	722.80	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	718.64	716.70	718.89	719.06	[illegible]	[illegible]	720.20	720.80	722.90	[illegible]	[illegible]
[illegible]	[illegible]	711.90	719.76	719.71	720.03	720.02	720.43	720.89	720.89	[illegible]	722.90	[illegible]	[illegible]
[illegible]	[illegible]	712.00	720.66	720.92	721.25	[illegible]	721.69	[illegible]	[illegible]	721.08	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	712.90	720.68	721.19	721.51	721.96	[illegible]	[illegible]	[illegible]	[illegible]	723.28	[illegible]	[illegible]
[illegible]	[illegible]	712.00	720.77	721.25	721.55	721.99	[illegible]	[illegible]	722.80	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	712.00	720.68	721.16	721.66	721.87	722.15	722.65	722.68	723.21	723.19	[illegible]	[illegible]
[illegible]	[illegible]	716.90	722.33	722.59	722.77	723.15	723.33	[illegible]	[illegible]	[illegible]	724.19	[illegible]	[illegible]
[illegible]	[illegible]	717.10	724.23	724.64	724.58	724.89	725.01	[illegible]	[illegible]	725.60	725.59	[illegible]	[illegible]
[illegible]	[illegible]	717.10	724.64	724.66	724.78	725.09	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	717.60	724.36	724.55	724.69	725.01	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	717.60	724.75	724.93	725.05	725.30	725.60	[illegible]	[illegible]	725.90	725.89	[illegible]	[illegible]
[illegible]	[illegible]	717.60	724.59	724.79	724.91	725.17	725.28	[illegible]	[illegible]	725.82	725.81	[illegible]	[illegible]
[illegible]	[illegible]	718.00	725.26	725.32	725.42	725.64	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	719.30	726.13	726.33	726.47	726.76	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	719.30	726.78	726.69	726.63	726.92	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	719.90	726.30	726.71	726.65	726.96	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	719.90	727.67	727.73	727.92	[illegible]	728.35	[illegible]	728.53	[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	720.10	727.65	727.69	727.91	728.27	728.31	[illegible]	728.53	728.76	[illegible]	[illegible]	
[illegible]	[illegible]	720.20	727.70	727.75	727.95	728.36	728.36	[illegible]	728.58	728.80	728.79	[illegible]	

[illegible] ... is shown on plate 4B 13 in the [illegible], Minnesota, Limited Reevaluation
Report
[illegible] upstream ... section 20.9
[illegible] elevation in the main channel
[illegible] hydrologic and hydraulic conditions
[illegible] hydrologic and hydraulic conditions

Table I-4

Risk and Hazard of a Potential Levee Failure at the Ten Critical Levee Locations shown on Figure 1

Critical Levee Location shown on Figure 1	Maximum Top of Freeboard Elevation in feet	Typical Ground Elevation Landward of Levee in feet	Head of Water on Barrier, with Water Surface at the Maximum Top of Freeboard Elev. in feet	Risk and Hazard with Water Surface at Top of Freeboard
1	719.5	719.5	0	Low
2	715.5	705.0	10.5	High
3	718.5	718.5	0	Low
4	720.0	720.0	0	Low
5	723.8	723.8	0	Low
6	724.0	724.0	0	Low
7	721.1	721.1	0	Low
8	724.0	724.0	0	Low
9	724.1	715.2	8.9	High
10	717.3	715.0	2.3	Low

Table 1-5

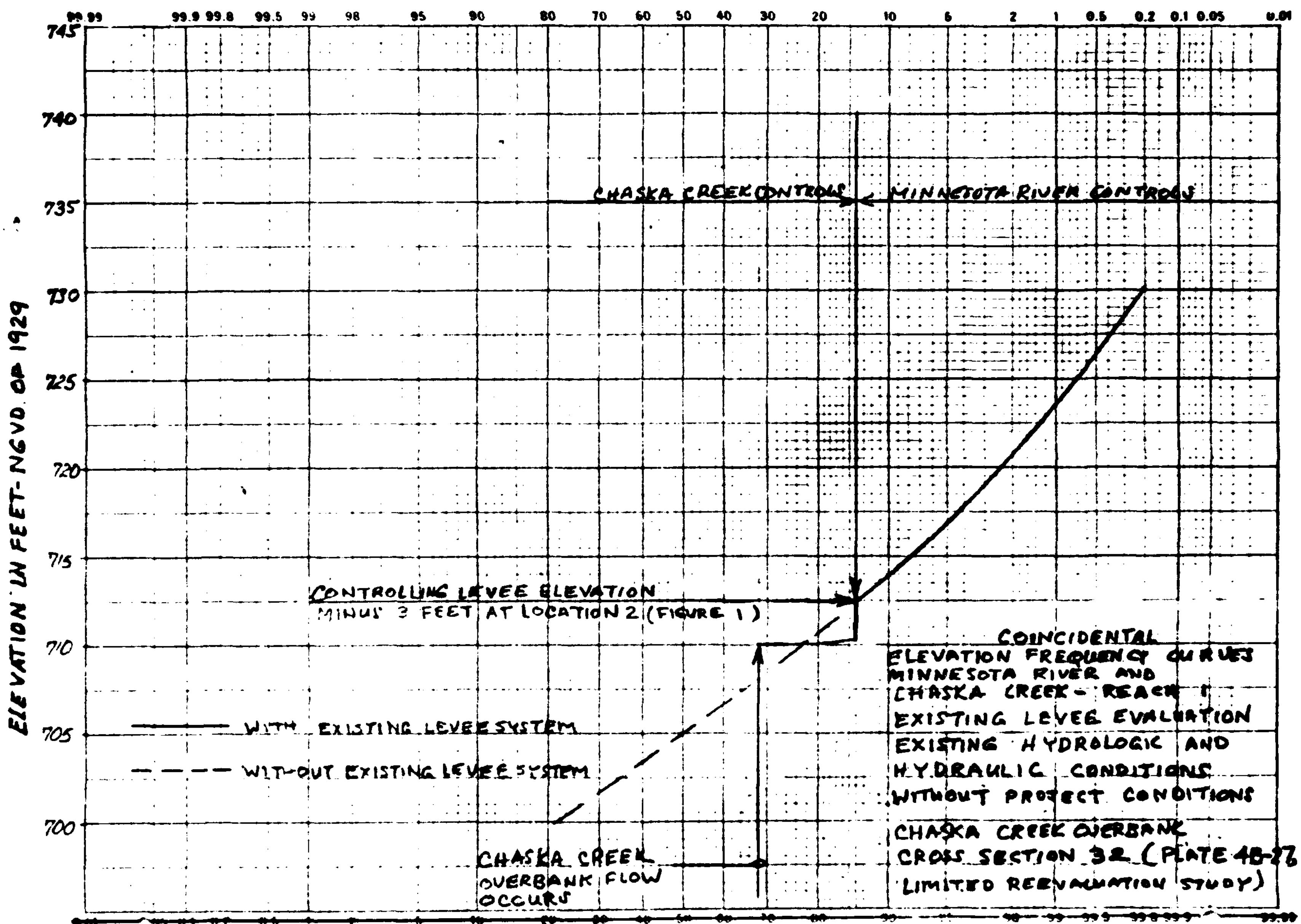
Cumulative Probability for Levee Overtopping
(For existing flood barrier at Chaska, Minnesota)

Recurrence Interval (in years)	Risk for Given Time Interval in Percent				
	5-year	10-year	20-year	50-year	100-year
2	97	100	100	100	100
3	85	98	100	100	100
5	67	89	99	100	100
7	50	74	94	100	100
10	40	65	88	99	100
11	36	59	83	93	100
15	29	50	75	94	100
20	22	40	64	92	99
25	18	34	56	87	98
33	16	29	49	82	97
50	10	18	33	64	87
59	9	16	30	58	82
100	5	10	18	39	63


WEST CHASKA CREEK
HICKORY STREET

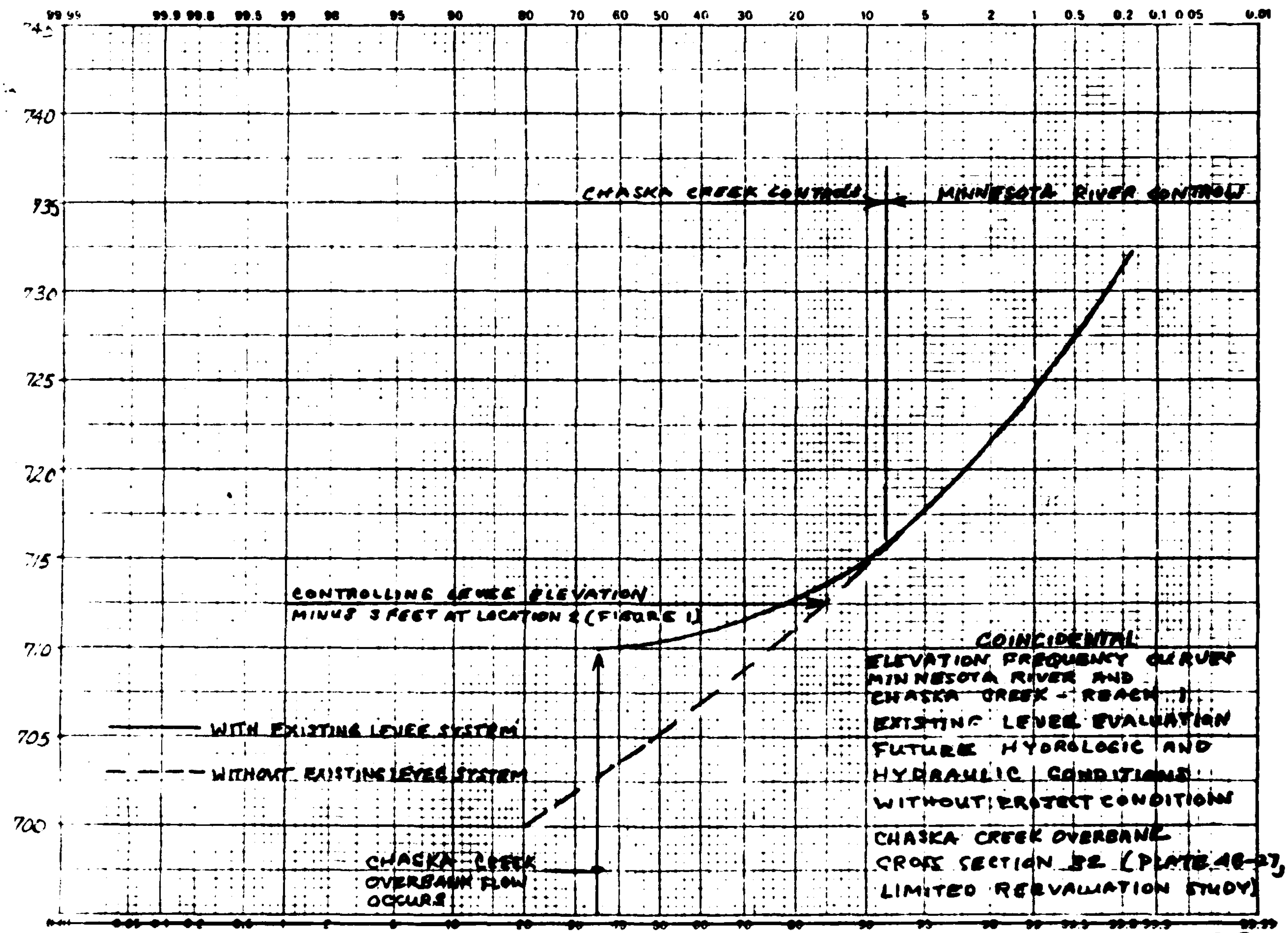
5
4a
4b
EAST CHASKA CREEK
3
2
ABANDONED RAILROAD EMBANKMENT
MINNESOTA RIVER
EXISTING EMERGENCY LEVEES
REQUIRED TEMPORARY CLOSURES
SEPARABLE LEVEE REACHES
CRITICAL LEVEE LOCATIONS
CHASKA: Emergency Levee Evaluation

FIGURE 1



ELEVATION IN FEET- NGVD OF 1929
745
740
735
730
725
720
715
710
705
700
99.99 99.9 99.8 99.5 99 98 95 90 80 70 60 50 40 30 20 10 6 2 1 0.5 0.2 0.1 0.05 0.01
CHASKA CREEK CONTROLS
MINNESOTA RIVER CONTROLS
CONTROLLING LEVEE ELEVATION
MINUS 3 FEET AT LOCATION 2 (FIGURE 1)
WITH EXISTING LEVEE SYSTEM
WITHOUT EXISTING LEVEE SYSTEM
CHASKA CREEK
OVERBANK FLOW
OCCURS
COINCIDENTAL
ELEVATION FREQUENCY CURVES
MINNESOTA RIVER AND
CHASKA CREEK - REACH 1
EXISTING LEVEE EVALUATION
EXISTING HYDROLOGIC AND
HYDRAULIC CONDITIONS
WITHOUT PROJECT CONDITIONS
CHASKA CREEK OVERBANK
CROSS SECTION 32 (PLATE 4B-76
LIMITED REEVALUATION STUDY)

FIGURE 2



CHASKA CREEK CONTROLS
MINNESOTA RIVER CONTROLS
CONTROLLING LEVEE ELEVATION MINUS 3 FEET AT LOCATION 2 (FIGURE 1)
WITH EXISTING LEVEE SYSTEM
WITHOUT EXISTING LEVEE SYSTEM
CHASKA CREEK OVERBANK FLOW OCCURS
COINCIDENTAL
ELEVATION FREQUENCY CURVES
MINNESOTA RIVER AND CHASKA CREEK - REACH 1
EXISTING LEVEE EVALUATION
FUTURE HYDROLOGIC AND HYDRAULIC CONDITIONS
WITHOUT PROJECT CONDITIONS
CHASKA CREEK OVERBANK CROSS SECTION 32 (PLATE 4B-27, LIMITED REEVALUATION STUDY)
700
705
710
715
720
725
730
735
740
745
99.99
99.9
99.8
99.5
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01

FIGURE 2

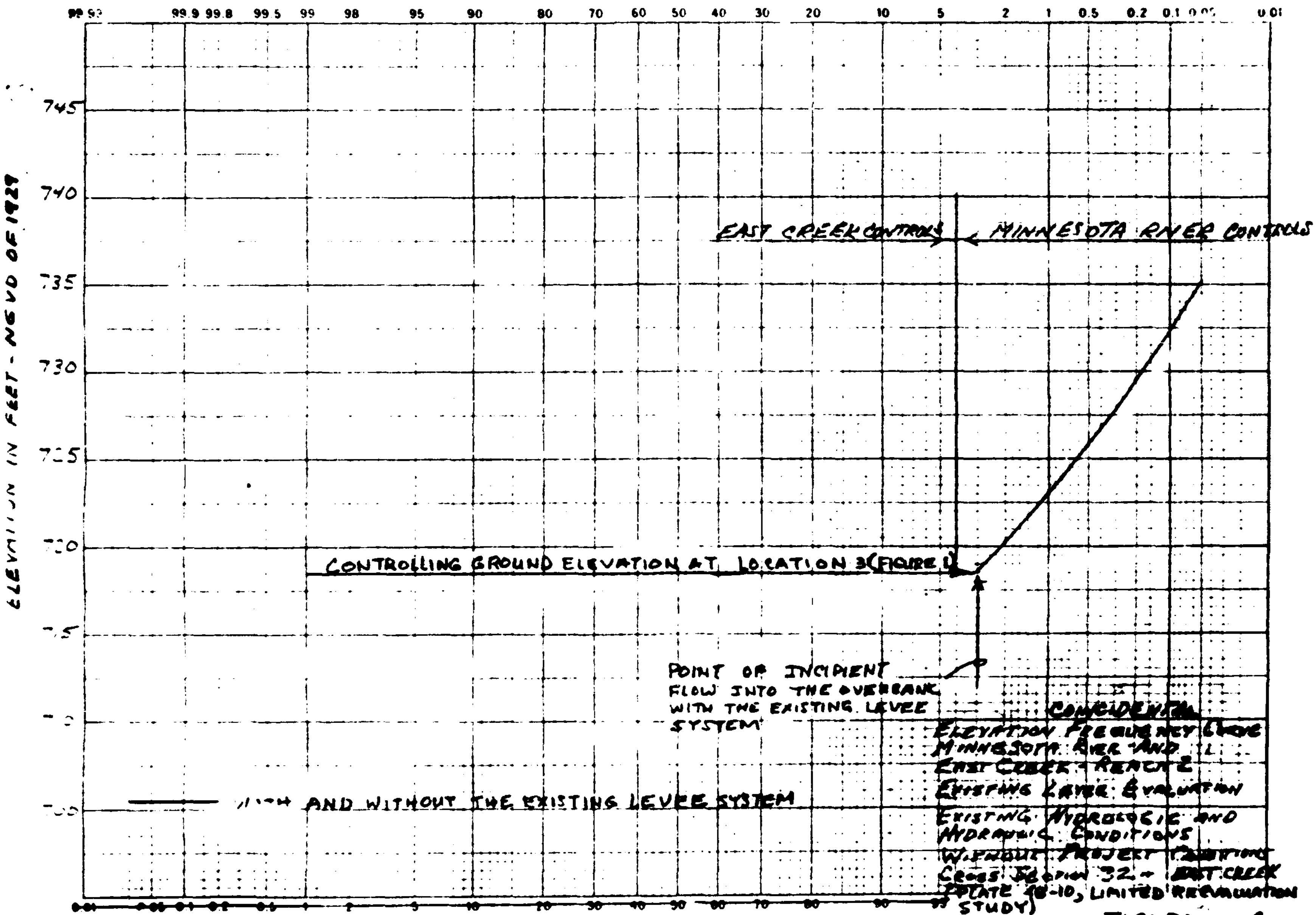
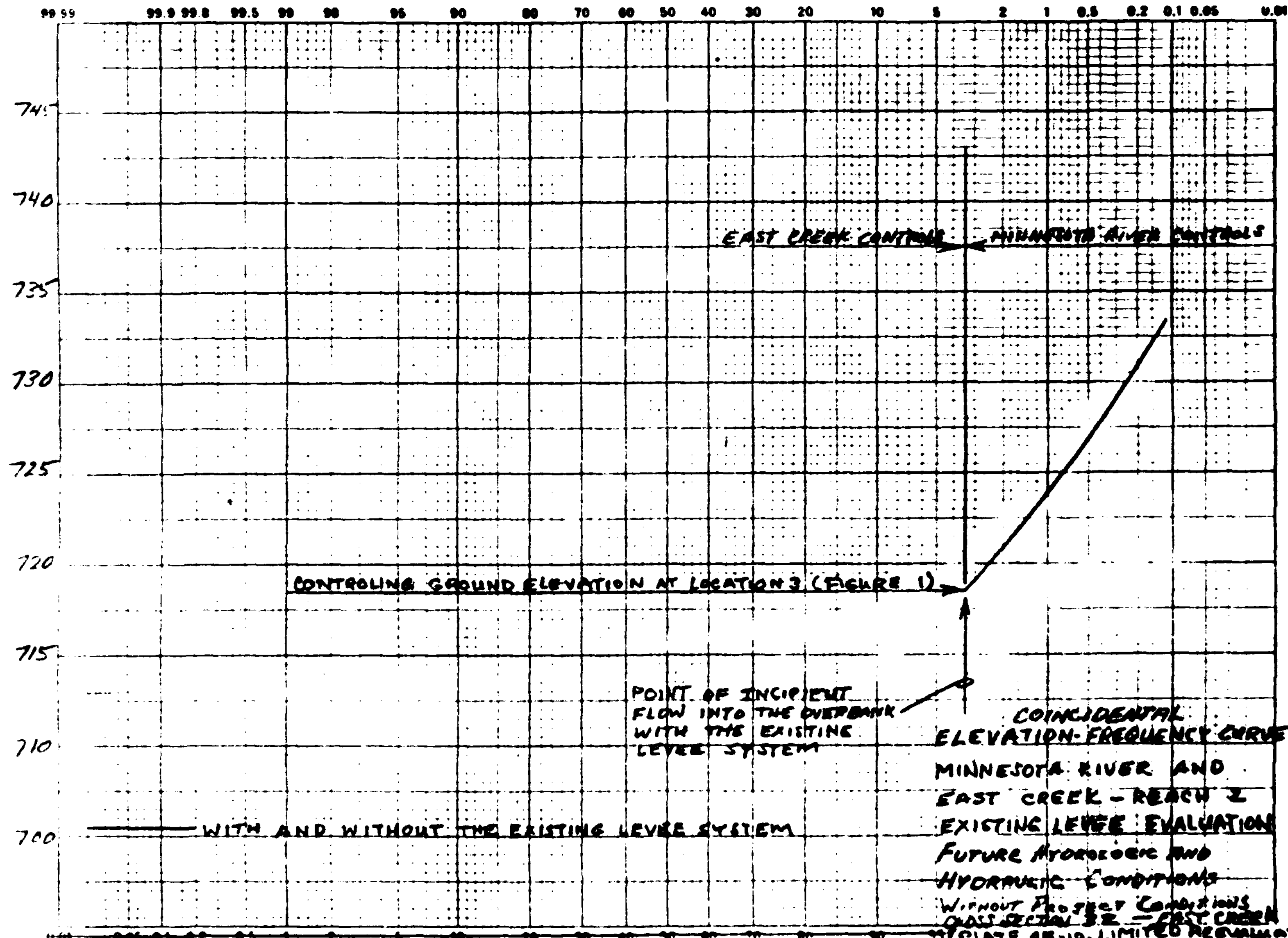
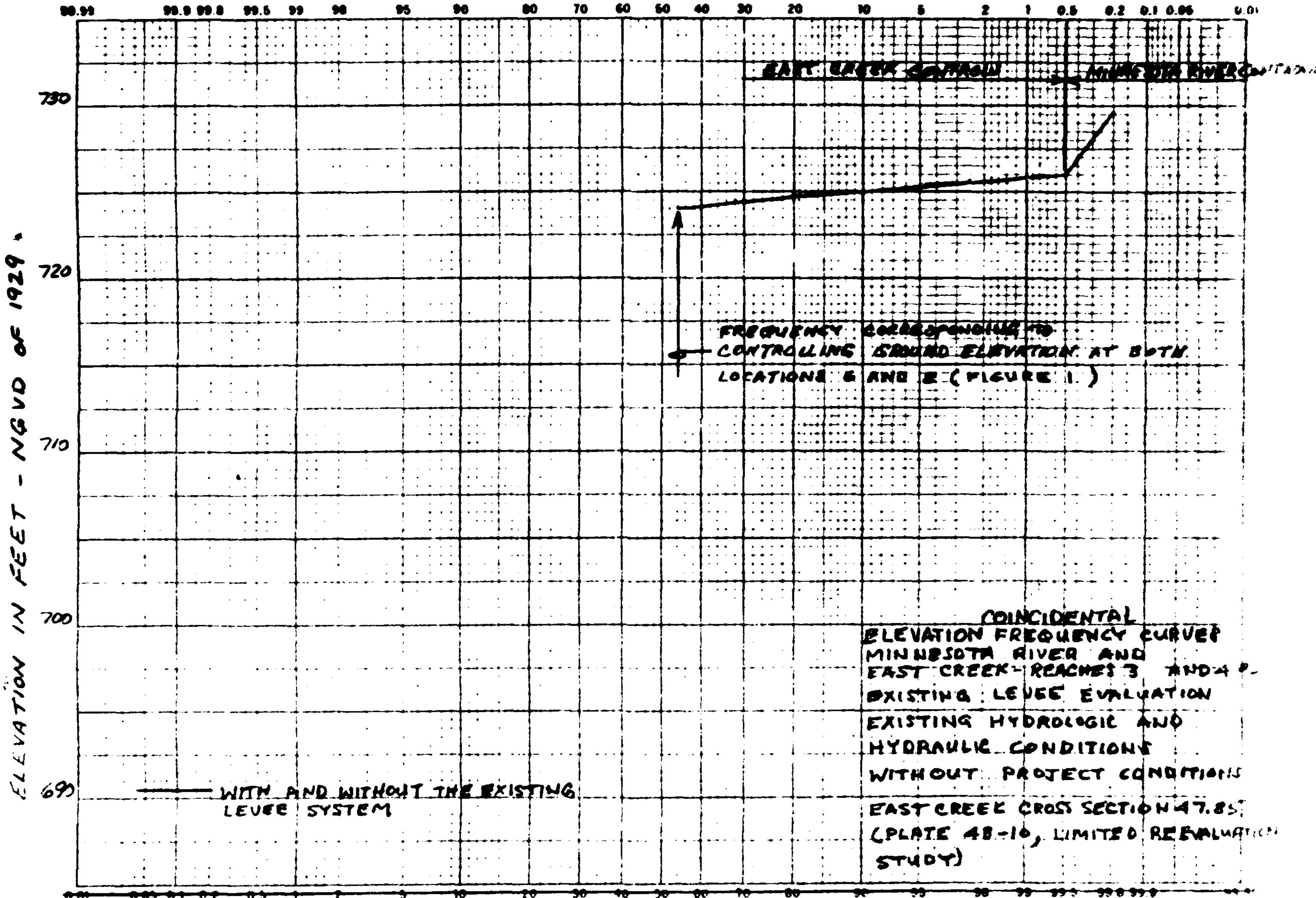

ELEVATION IN FEET - NGVD OF 1929
99.99 99.9 99.8 99.5 99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 0.5 0.2 0.1 0.05 0.01
745
740
735
730
725
720
715
710
705
EAST CREEK CONTROLS
MINNESOTA RIVER CONTROLS
CONTROLLING GROUND ELEVATION AT LOCATION 3 (FIGURE 1)
POINT OF INCIPIENT FLOW INTO THE OVERBANK WITH THE EXISTING LEVEE SYSTEM
AND WITHOUT THE EXISTING LEVEE SYSTEM
CONFIDENTIAL
ELEVATION FREQUENCY CURVE
MINNESOTA RIVER AND EAST CREEK - REACH 2
EXISTING LEVEE EVALUATION
EXISTING HYDROLOGIC AND HYDRAULIC CONDITIONS
WITHOUT PROJECT CONDITIONS
CROSS SECTION 32 - EAST CREEK
(PLATE 18-10, LIMITED REEVALUATION STUDY)

FIGURE 4



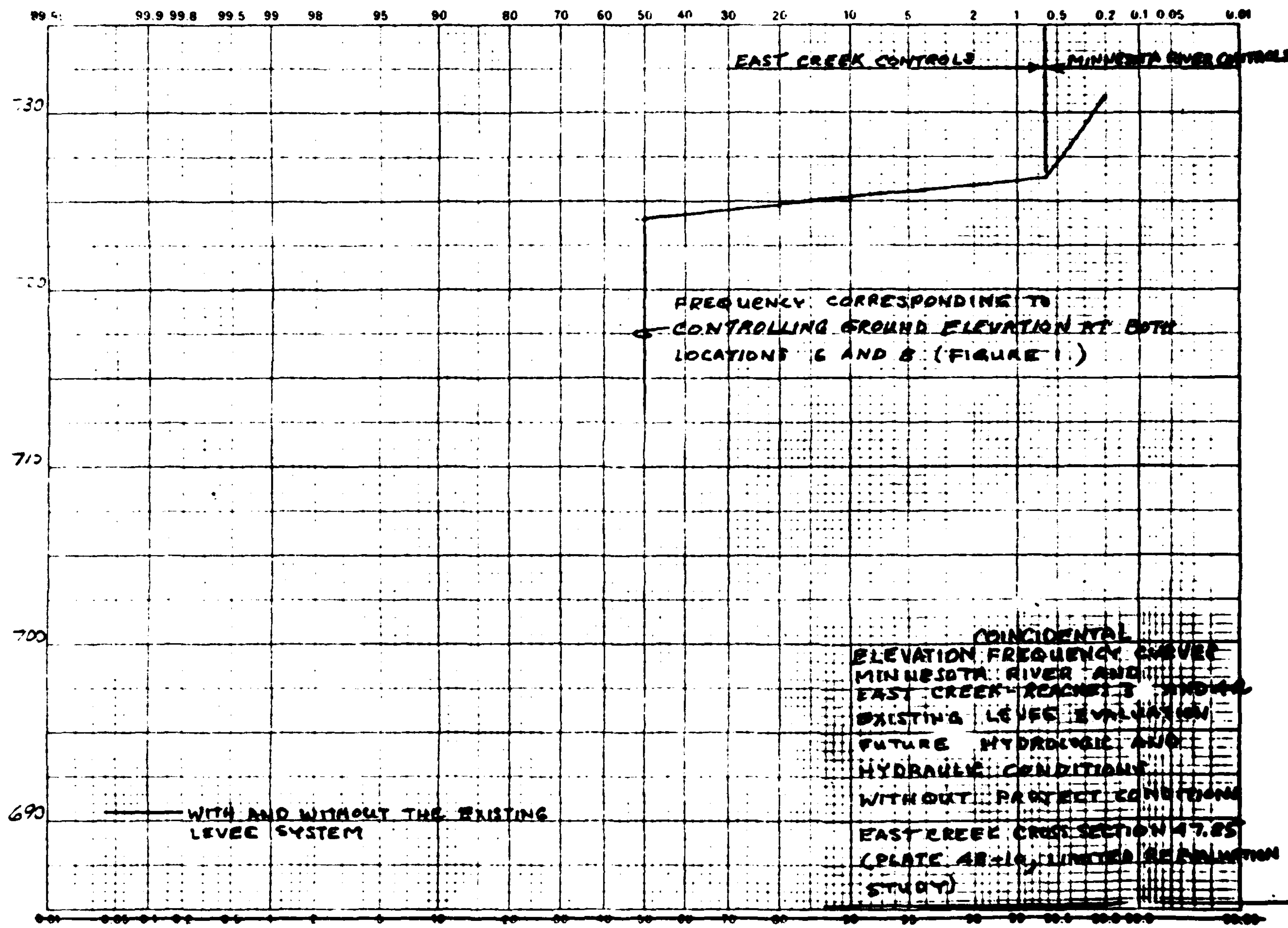
COINCIDENTAL
ELEVATION-FREQUENCY CURVE
MINNESOTA RIVER AND
EAST CREEK - REACH 2
EXISTING LEVEE EVALUATION
FUTURE HYDROLOGIC AND
HYDRAULIC CONDITIONS
WITHOUT PROJECT CONDITIONS
CROSS SECTION 32 - EAST CREEK
(PLATE 4B-10, LIMITED REEVALUATION STUDY)

FIGURE 5



ELEVATION IN FEET - NGVD OF 1929
730
720
710
700
690
99.99
99.9
99.8
99.5
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
EAST CREEK CONTROLS
MINNESOTA RIVER CONTROLS
FREQUENCY CORRESPONDING TO CONTROLLING GROUND ELEVATION AT BOTH LOCATIONS 6 AND 2 (FIGURE 1)
WITH AND WITHOUT THE EXISTING LEVEE SYSTEM
COINCIDENTAL
ELEVATION FREQUENCY CURVES
MINNESOTA RIVER AND
EAST CREEK - REACHES 3 AND 4
EXISTING LEVEE EVALUATION
EXISTING HYDROLOGIC AND
HYDRAULIC CONDITIONS
WITHOUT PROJECT CONDITIONS
EAST CREEK CROSS SECTION 47.85
(PLATE 48-10, LIMITED REEVALUATION
STUDY)

FIGURE 6



99.99
99.9 99.8
99.5
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1 0.05
0.01
730
720
710
700
690
EAST CREEK CONTROLS
MINNESOTA RIVER CONTROLS
FREQUENCY CORRESPONDING TO CONTROLLING GROUND ELEVATION AT BOTH LOCATIONS 6 AND 8 (FIGURE 1)
WITH AND WITHOUT THE EXISTING LEVEE SYSTEM
COINCIDENTAL ELEVATION FREQUENCY CURVE
MINNESOTA RIVER AND EAST CREEK REACHES 3 THRU 6
EXISTING LEVEE EVALUATION
FUTURE HYDROLOGIC AND HYDRAULIC CONDITIONS
WITHOUT PROJECT CONDITIONS
EAST CREEK CROSS SECTION 47.85
(PLATE 48-10, LIMITED REEVALUATION STUDY)

FIGURE 7

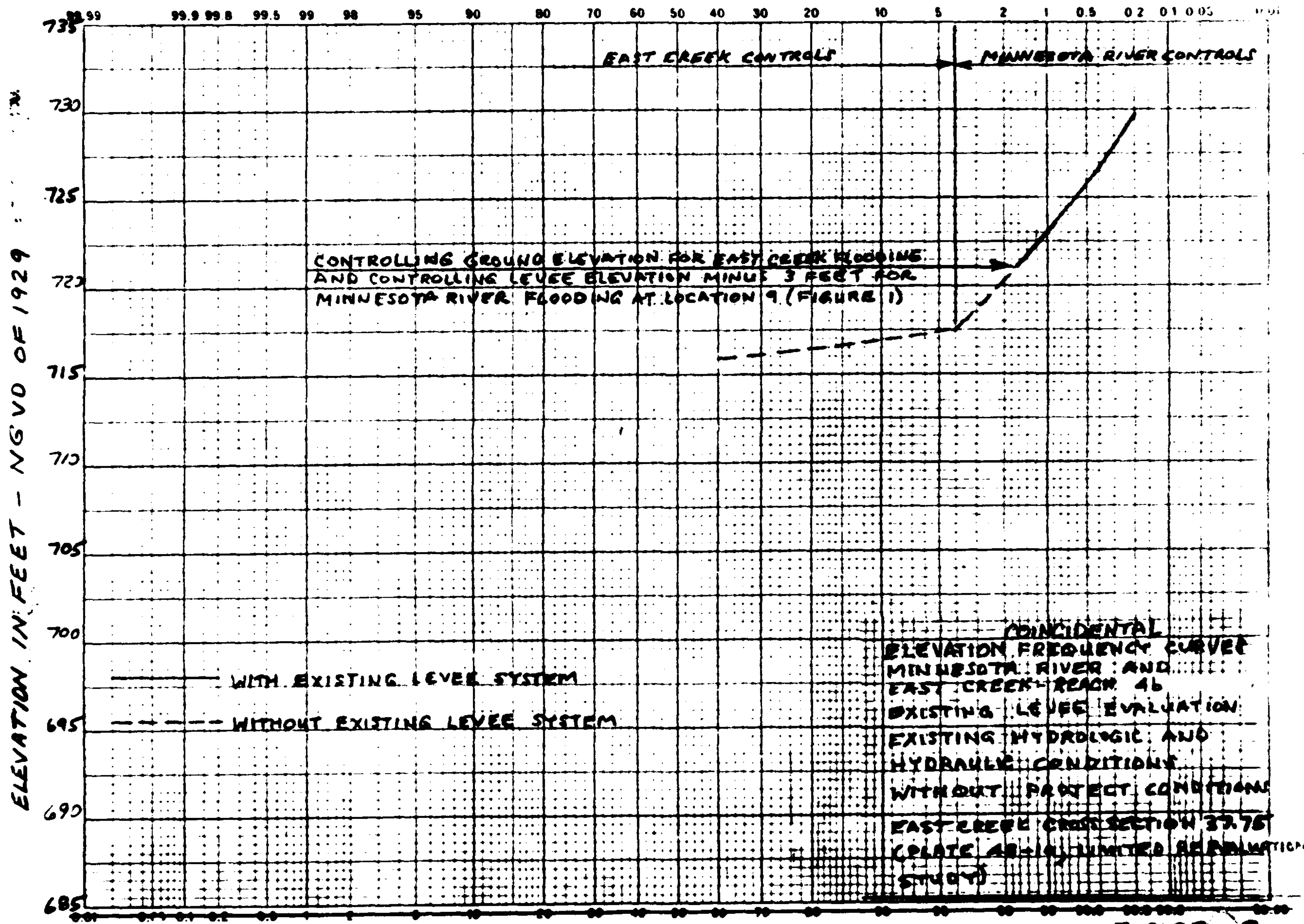
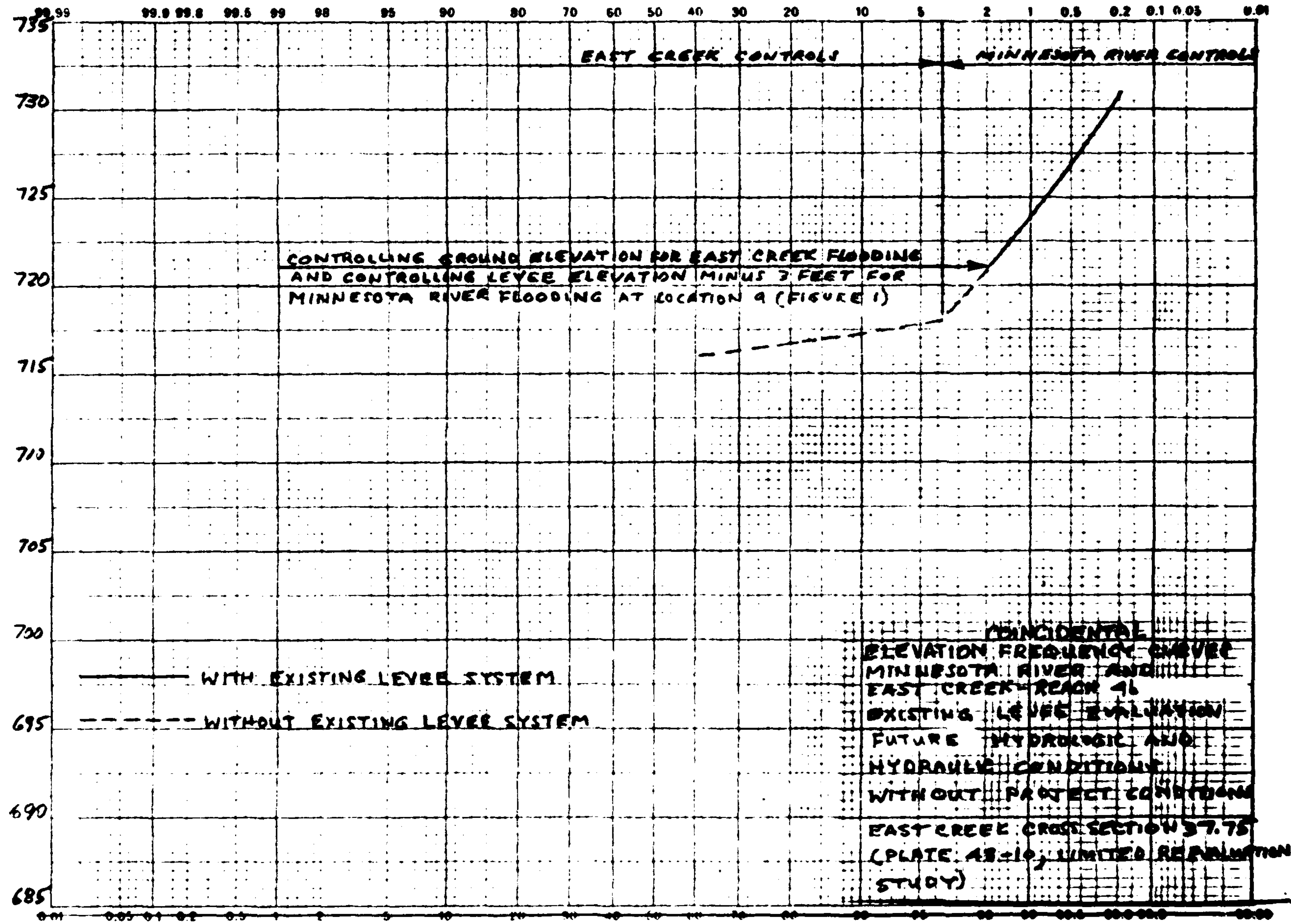

ELEVATION IN FEET - NGVD OF 1929
EAST CREEK CONTROLS
MINNESOTA RIVER CONTROLS
CONTROLLING GROUND ELEVATION FOR EAST CREEK FLOODING AND CONTROLLING LEVEE ELEVATION MINUS 3 FEET FOR MINNESOTA RIVER FLOODING AT LOCATION 9 (FIGURE 1)
WITH EXISTING LEVEE SYSTEM
WITHOUT EXISTING LEVEE SYSTEM
COINCIDENTAL
ELEVATION FREQUENCY CURVES
MINNESOTA RIVER AND
EAST CREEK - REACH 4b
EXISTING LEVEE EVALUATION
EXISTING HYDROLOGIC AND
HYDRAULIC CONDITIONS
WITHOUT PROJECT CONDITIONS
EAST CREEK CROSS SECTION 37.75
(PLATE 48-14, LIMITED REEVALUATION STUDY)

FIGURE 8



EAST CREEK CONTROLS
MINNESOTA RIVER CONTROLS
CONTROLLING GROUND ELEVATION FOR EAST CREEK FLOODING AND CONTROLLING LEVEE ELEVATION MINUS 3 FEET FOR MINNESOTA RIVER FLOODING AT LOCATION 9 (FIGURE 1)
WITH EXISTING LEVEE SYSTEM
WITHOUT EXISTING LEVEE SYSTEM
COINCIDENTAL ELEVATION FREQUENCY CURVE
MINNESOTA RIVER AND EAST CREEK-REACH 46
EXISTING LEVEE EVALUATION
FUTURE HYDROLOGIC AND HYDRAULIC CONDITIONS
WITHOUT PROJECT CONDITIONS
EAST CREEK CROSS SECTION 37.75 (PLATE 43-10, LIMITED REEVALUATION STUDY)
735
730
725
720
715
710
705
700
695
690
685

FIGURE 9

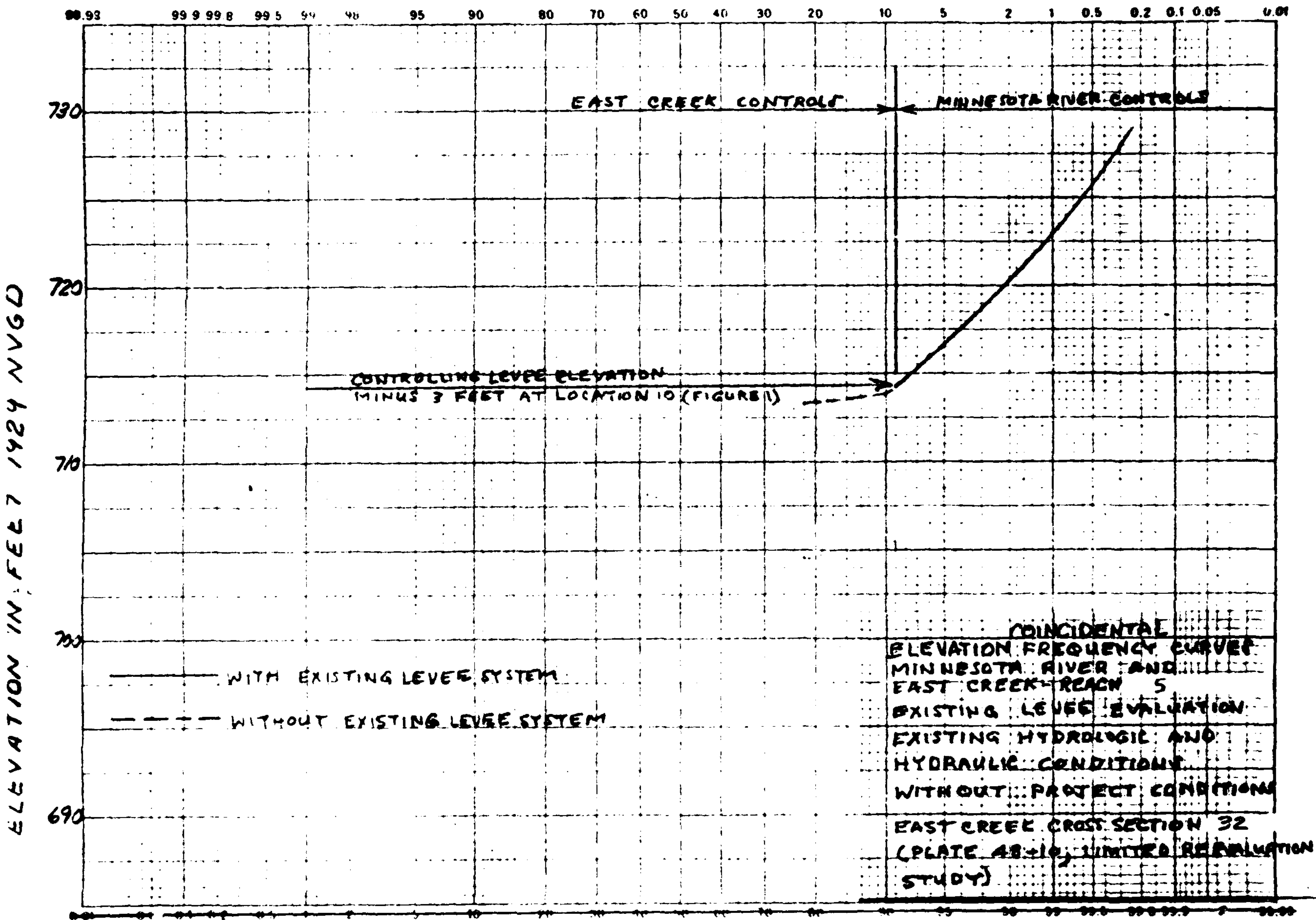

ELEVATION IN FEET 1924 NVGD
99.93
99.9 99.8
99.5
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
730
720
710
700
690
EAST CREEK CONTROLS
MINNESOTA RIVER CONTROLS
CONTROLLING LEVEE ELEVATION
MINUS 3 FEET AT LOCATION 10 (FIGURE 1)
WITH EXISTING LEVEE SYSTEM
WITHOUT EXISTING LEVEE SYSTEM
COINCIDENTAL
ELEVATION FREQUENCY CURVES
MINNESOTA RIVER AND
EAST CREEK-REACH 5
EXISTING LEVEE EVALUATION
EXISTING HYDROLOGIC AND
HYDRAULIC CONDITIONS
WITHOUT PROJECT CONDITIONS
EAST CREEK CROSS SECTION 32
(PLATE 48-10, LIMITED REEVALUATION
STUDY)

FIGURE 10

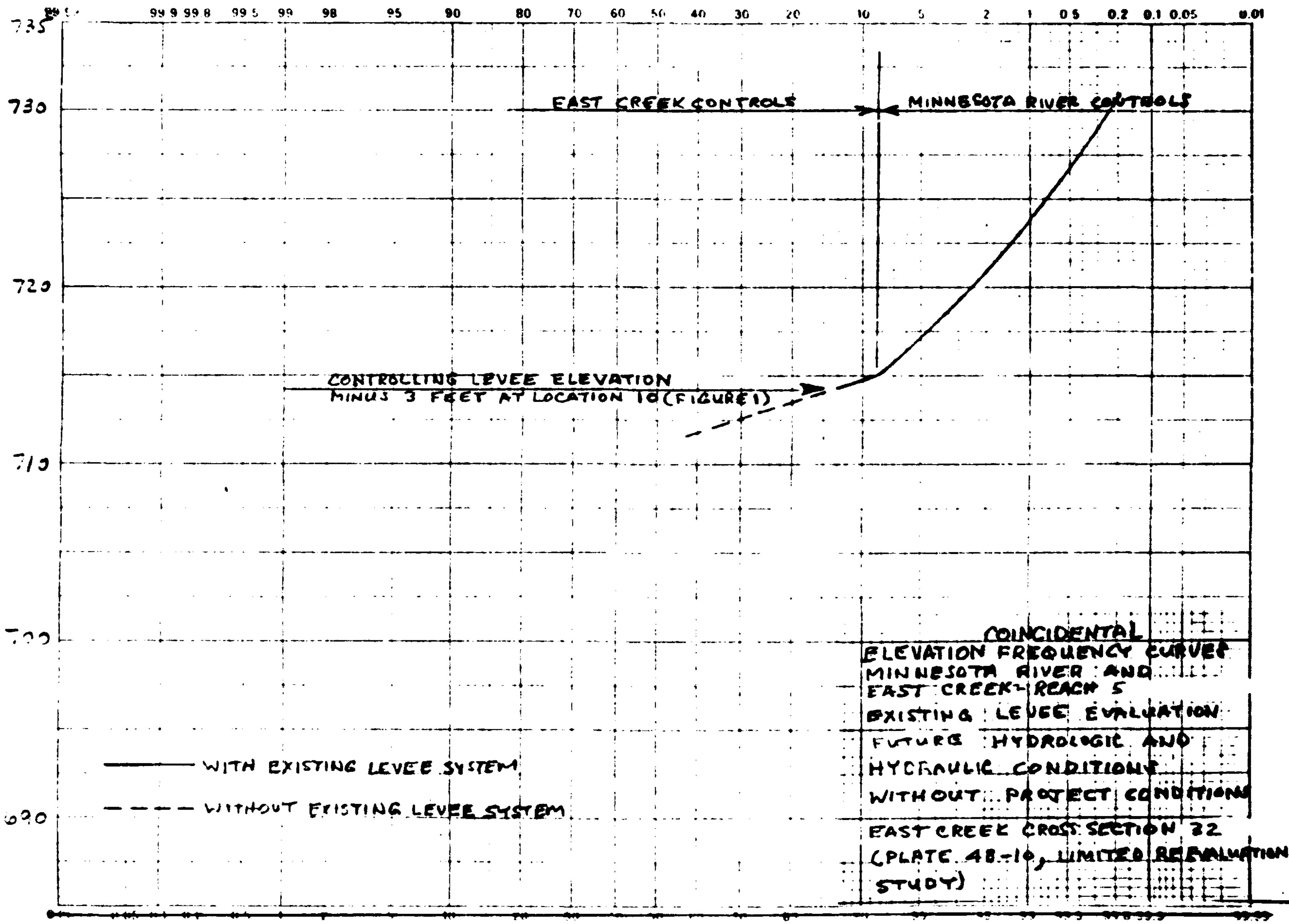

99.99
99.9 99.8
99.5
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1 0.05
0.01
735
730
720
710
700
690
EAST CREEK CONTROLS
MINNESOTA RIVER CONTROLS
CONTROLLING LEVEE ELEVATION
MINUS 3 FEET AT LOCATION 10 (FIGURE 1)
WITH EXISTING LEVEE SYSTEM
WITHOUT EXISTING LEVEE SYSTEM
COINCIDENTAL
ELEVATION FREQUENCY CURVES
MINNESOTA RIVER AND
EAST CREEK - REACH 5
EXISTING LEVEE EVALUATION
FUTURE HYDROLOGIC AND
HYDRAULIC CONDITIONS
WITHOUT PROJECT CONDITIONS
EAST CREEK CROSS SECTION 32
(PLATE 48-10, LIMITED REEVALUATION
STUDY)

FIGURE 11

END

DATE
FILMED

1 -85